STIMULATING INDUSTRIAL INNOVATION FOR SUSTAINABILITY:

AN INTERNATIONAL ANALYSIS

Final Report

Erik Frinking
James P. Kahan
Mari Pöyhönen

RAND Europe
RE-2000.15

1 October 2000

PREFACE

This report, prepared for and funded by the Netherlands Ministry of Housing, Spatial Planning, and the Environment, presents the results of an international analysis of government programs and initiatives aimed at stimulating innovation and sustainable development. The main objective was to find out whether the Dutch government can learn from such foreign initiatives and incorporate certain elements in its own ongoing programs and initiatives.

The research was conducted by a consortium under the leadership of RAND Europe and consisted of Lisberg Consultants (Denmark), Prognos (Germany), Solving, Bohlin & Stromberg (Sweden), and Solving International (France, Italy), and the RAND offices in Leiden, the Netherlands and Washington, DC, United States.

The research project lasted from 1 January 2000 until 1 October 2000. Actual data collection took place between 1 February 2000 and 1 June 2000. The report is organized in two volumes. The first volume is an overall analysis based on the examination of individual countries complemented by knowledge and expertise of related studies. This overall analysis does not contain overview of activities per country. The second volume is a collection of nine individual country reports, i.e. Austria, Belgium, Denmark, Finland, France, Germany, Sweden, the United Kingdom, and the United States. These country reports all follow a similar format: a description of institutional context, a classification of the different policy instruments in use, and a detailed description of the most interesting initiatives.

This report has been peer reviewed and it has been reviewed by a steering group consisting of Mr. ir. Just van Lidth de Jeude (project coordinator, Ministry of Housing, Spatial Planning, and the Environment), Ms. Edith Engelen (Novem), Ms. drs. Annelieke Kwak (Ministry of Housing, Spatial Planning, and the Environment) Mr. ir. Jan Pieter Mook (Ministry of Economic Affairs), and Mr.dr. Frans Vollenbroek (Ministry of Housing, Spatial Planning, and the Environment). We would like to acknowledge their guidance and comments. We would also like to thank our former colleague Sandy Bosman for all her work on this project. Conclusions in this report are RAND Europe's alone and should not be ascribed to any other organizations involved.

The report should be of interest to government officials dealing with managing investment programs related to innovation and sustainable development, policymakers in the domain of technology policy, researchers studying the field of science and technology, and research and development centers in private companies.

For more information about RAND Europe or this document, please contact:

drs. Erik Frinking
Research Leader
RAND Europe
Newtonweg 1
2333 CP Leiden
The Netherlands
ph.: 31 71 524 51 51
fax: 31 71 524 51 91
email: Erik_Frinking@rand.org

TABLE OF CONTENTS

EXECUTIVE SUMMARY

POLICY CONTEXT

The Netherlands is currently experiencing high economic growth. This economic growth allows the Dutch government to balance its budget, decrease income taxation of its citizens, and to promote economic conditions for the private sector. However, this growth can trigger some negative consequences in the field of transportation, education, and environment among others. Sometimes, it requires government measures to deal with these consequences that in themselves can counter economic growth. Clearly, this is a dilemma that the Dutch government has addressed for over a decade now. Policy objectives and measures have been formulated in such a manner that a decoupling between economic growth and its negative impacts is accomplished. In that respect, it is often not sufficient to simply pursue a further optimization or improvement of technologies as this approach often results in "less growth of burden per growth of economy," but still produces a growth in the environmental burden. Instead, new methods of production, logistical concepts, or even different approaches towards defining and fulfilling needs are required. A very important approach has been the stimulation of research and technology development and the subsequent use of new products and processes.

There are already a significant number of programs implemented in the Netherlands that aim at stimulating such approaches. Beyond subsidy of research, attention is turning to other policy instruments that might further these goals. These instruments are not only financial in nature (e.g., selective tax incentives), but also non-economic (e.g., government as a knowledge broker, government as opinion leader). Here, too, the Dutch government, through the actions of various ministries singly and in combination, has been active.

Other industrialized nations as well as the European Union itself give a high priority to further research to better understand the possibilities of decoupling economic growth and environmental burden and to the development of measures to reduce the burden. It is therefore efficient from both the research perspective and the development perspective that different efforts to reduce the environmental burden be aware of and capitalize on the experiences of each other, even as countries compete to be the first or the best in this regard.

It is exactly with this purpose in mind that the Netherlands Ministry of Housing, Spatial Planning, and the Environment commissioned an international analysis that could highlight promising initiatives and developments in the field of innovation toward sustainable development in other countries. The results should help the entire Dutch government in strengthening and augmenting its initiatives by learning from others and building on current programs that are perceived as already successful.

APPROACH

RAND Europe used several criteria to select countries that could provide interesting comparison points and lessons for the Dutch situation. First of all, we included countries where sustainable development issues are differently perceived, presuming that this would lead to a different use of instruments and design of programs. Second, we sought countries where the investments in research and technology development were of considerably different size. Third, we examined a range of countries with different national innovation systems and therefore different context characteristics. Finally, we did not want to omit larger European countries as they often prove to be leaders in the developments in a policy area. For each of these criteria, we wanted to make sure that countries that had similar characteristics as the Netherlands were included. Applying these criteria, the following ten countries were selected for the survey: Austria, Belgium, Denmark, France, Finland, Germany, Italy, Sweden, United Kingdom and the United States.

Our data collection was guided by the use of an analytic framework that rested on a number of relevant dimensions. First, this framework considered the institutional context of each country, including the institutional roles played by the different actors within national innovation systems and national systems for sustainability. This led to a consideration of the variety of roles that government can play within these systems. The implementation of the roles in policy instruments followed logically from a consideration of the roles. The following table presents these categories of different technology policy instruments presented in this study and provides examples of specific instruments.

Main category of instruments	**Subcategory of instruments**	**Examples of types of instruments**
Instruments financing knowledge infrastructure	Direct subsidies for selected actors	• Institutional funds • Program funds • Project funds • Build up physical infrastructure to support knowledge infrastructure
	Supply of capital	• Different types of loans given by government • Government as co-investor in a company • Public-privately owned research institutes
	Financial and economic incentives	• Loan guarantees (guarantee for bank loan, guarantee against losses) • Tax incentives
Instruments stimulating, leading, and catalyzing technology development	Knowledge management and transfer instruments related to 1) Networking, 2) Human capital, and 3) Creating new business and supporting business operations	• Centers of excellence • Awards • Science parks • Information collection and dissemination • Consulting services • Networking instruments • Joint research centers with foreign governments • Encourage mobility of researchers • Encourage mobility of workforce
	Participatory instruments	• Mandatory "green procurement" • National procurement information centers • Government demonstration projects • Public-private partnerships (pilot projects)
Instruments facilitating the regulatory conduct of business	Laws and regulations	• Environmental legislation • Taxation • Intellectual property rights
	Voluntary Standards	• Emission trading schemes • Green labeling • Voluntary individual agreements • Performance standards • Environmental management systems

We assembled an international team of researchers to collect the necessary data in the selected countries. To streamline these activities, we took a three-step approach. First, we organized a workshop to discuss the available background materials, determine research priorities, and finalize the development of the information collection tools and ensure that all the researchers understood their use. Second, team members collected information about

interesting initiatives by conducting desk research and conducting in-depth interviews. In a second workshop, results for each country were presented and discussed, and assessed on their completeness. Third, based on the information and insights from the different countries, RAND Europe researchers analyzed the lessons learned per country for their applicability to the Netherlands.

CONCLUSIONS

Several trends emerged from our analysis of the efforts to stimulate innovation in industry for sustainability. A key to our observations is the distinction between countries that have not yet adapted the paradigm shift regarding the environmental burden of economic activity and those that have. This latter group, which we term "mature," provides experiences that are of potential value to the Dutch.

Observed trends and developments

Based on the distinction mentioned above, we observed the following trends across the more mature countries:

- **Gradual shift from basic research to implementation (… and back?)**

Governments have a tendency to provide increasing support to initiatives on a project by project basis and with more practically oriented objectives than to basic scientific research. The greater importance and involvement of industries and the increased awareness of connecting public and private actors have also created more emphasis on the need for more market-oriented product development and implementation than on basic research. The role of SMEs is becoming increasingly prominent in a number of European countries. Many government instruments are thus targeted to sharing the risks of SMEs.

- **Greater emphasis on promoting knowledge transfer and public-private partnerships**

Governments increasingly use a wider set of instruments to promote the dissemination of knowledge about technology development and the establishment of public-private partnerships (PPPs). The programs used to serve this purpose are varied, but a considerable emphasis is put on establishing networks joining smaller and larger enterprises, private sector research and public research institutes, as well as providing guidelines and standards to support business operations.

- **Emphasis on combination of policy instruments**

A reorientation of instruments used for stimulating sustainable development and innovation has taken place. The current strategies are very much pushing a multi-instrument approach (e.g., economic and knowledge management instruments combined) rather than a single instrument approach.

- **Increased use of market processes (e.g. voluntary, green labeling)**

As governments attempt to realize the objectives of presenting the benefits of new technologies and verifying their technical feasibility, the number of green labeling programs and the development of standards from the perspective of potential users are increasing.

- **Sustainable development as an integral part of policymaking**

Governments that have put high priorities on sustainable development issues are pursuing a strategy that actively integrates sustainability in all sector policies. Newer initiatives aim at incorporating sustainable development concerns in the policymaking processes in the areas of agriculture, energy, transportation, and commerce.

Potential areas for progress

Despite the perceived progress made in several countries, there are still remaining problems that will need resolution.

- **Effects of the use of instruments on innovation in industry is rather unclear**

Unfortunately, while the mature countries manifest more advanced thinking, we did not find an indication that the instruments that they use and the themes that they focus on are more effective in reaching goals pertaining to sustainable development. As a matter of fact, it is exactly the absence of these indications that stress the need for more intensive research and evaluation of the impact of the newer types of instruments.

- **Industries do not always accept the objectives and designs of government programs**

The availability of venture capital in the private market makes support from government less attractive, especially if that support comes with regulatory strings attached. As a consequence, even though governments might still be prepared to allocate large budgets to the funding of basic research and technology development in the private sector, these funds could go begging, especially in ventures considered having relatively lower risk.

- **Link between specific technology expertise and business development can be lacking**

Government organizations that have to select and prioritize ideas and products increasingly face a limited capacity to assess projects comprehensively on their technological, social and commercial merits. Despite the successful use of specialized intermediary agencies who possess that comprehensive capacity, government organizations are experiencing side effects in terms of difficulty keeping up with technological developments and getting slowed down by bureaucratic procedures.

Recommendations for the Netherlands

Based on our experiences with the countries that were included in our survey and our understanding of the Dutch policy context, we can conclude with some recommendations for Dutch policy.

- **Nobody else is the Netherlands**

None of the examined countries provides a model for which the Netherlands should be aiming. We found in an examination of ten different countries ten different ways in which the government engages technology development, sustainability, and the private sector. Different policy philosophies and different national characteristics only add to this already varied picture and make imitation more a harmful than a fruitful approach. In addition, some of the countries that could be interesting as potential models are currently undergoing discussions about reforming their own structures, often looking to the Netherlands for inspiration.

- **Choose a diverse mix à la carte**

While there is no specific country model to be followed, we have encountered many interesting programs and initiatives covering a wide range of possibilities. Given the increasing emphasis that is being put on a multi-instrument approach, it would seem most valuable to cover all bases, being inspired by the most interesting cases.

Among the cases presented, highly focused projects seem to be a key to success. The focus itself can vary widely, depending on the individual project, concentrating on:

- **geographic compactness** (e.g. focus on regional or even community level instead of on the national level). In some of the countries involved in this study highly successful projects have been launched on regional and city levels (e.g. Austria and Germany)
- **small changes;** incremental, bottom-up changes seem to have better results than revolutionary changes, since acceptance (both by the public, industry and the political

arena) is crucial (see Sweden). This is especially true when large technological changes have significant cultural resistance (e.g., genetically modified foods).
- **specific well-defined sectors of industry**; e.g. programs with a clear focus on SMEs or a particular industry seem to have a relatively high chance for success, compared to more general programs in which all kinds of industries are involved.

At the same time, ongoing efforts to mobilize large international teams or large-scale efforts should certainly not be abandoned. However, these larger efforts will eventually require implementation in more tightly defined geographical and sectoral areas.

While the Dutch portfolio in the area of sustainable development already covers a wide range of instruments, the "green procurement" instrument seems relatively unused in the Netherlands. In addition, there is empirical evidence that emission trading schemes, not fully developed in the Netherlands, have positive impacts on innovation and/or investment in technology development. The preparatory efforts in the Netherlands for the introduction of these schemes therefore seem worthwhile to continue.

- **Include industry in priority setting**

It is not a great insight to realize that the objectives and priorities of governments and private sector organizations are different, but taking those differences into account in instrument implementation is an art that is not fully realized. Although a company might be interested in incorporating issues such as preserving the environment in their objectives, not many businesses are ready to invest in the environment if they do not consider it economically feasible. Changing societal values and the environmental awareness of consumers might actually induce industries to invest in sustainable technology. Governments can play a role in creating mutual understanding of values and priorities, while industries can inform about the feasibility and viability of promoting certain technologies. Public-private partnerships are important vehicles but the inclusion of industry in priority setting remains important. This involvement should not ignore issues, which may create situations where government and industry goals could clearly conflict.

- **Learn how society can be receptive to promoting sustainable technology**

Open exchange of information is crucial to stimulate sustainable innovation in industry. However, we don't know yet the answer to the question**:** What causes a **population** to be receptive to promoting sustainable technology? This might have to do with attitude of a population toward sustainability and environmental issues, which might be related to the economic well being of the country (now and in the past), in combination with the organizational and constitutional structure of a country etc. We noted differences in the maturity of developed European countries in adopting the paradigm shift of sustainability, but none of our analyses—nor country categorizations in the innovation literature—successfully explained which countries adopted and which countries did not adopt the paradigm shift or why this happened. While certain countries have established initiatives to focus production of new technology that are based on the functionality and requirements that users might want, most countries still follow the path of developing those technologies that are most easily developed. No clear answer has emerged from our research, but this would seem to be one of the most fundamental issues in stimulating and accepting innovation for sustainability.

1. INTRODUCTION

1.1. BACKGROUND

The Netherlands has in recent years enjoyed economic prosperity. This has been manifested in growth in Gross Domestic Product (GDP) and employment, accompanied by a significant decrease in unemployment and government deficits. The Dutch have successfully adapted to the rapid changes in market conditions accompanying the globalization of business and explosion in information technology. This adaptation has profoundly changed the Dutch economic structure. Possibly as a consequence of this success, Dutch economic, environmental and technological policies have become focused on finding a balance between economic development and sustainable growth in a socially and environmentally responsible way. A major component of this policy shift has been a search for ways to promote economic growth while at the same time decreasing the environmental burden that has often increased as the result of such growth.

In pursuit of further improvement of the environment, it is necessary to further leverage this "decoupling" of economic growth and environmental burden. As indicated in the *Nota Milieu en Economie*[1], it will not suffice to simply pursue a further optimization or improvement of technologies, because that would only result in "less growth of burden per growth of economy," but still produce a growth in the environmental burden. Instead, new production methods, logistical concepts, research or even different approaches towards defining and fulfilling needs are necessary.

To meet these requirements calls for a long-term perspective. Investments in research aiming at breakthrough technologies are inherently risky, but they are necessary. In order to spread the risk, "society at large," as represented by the government, must be a partner in investment. An early implementation of policy in this direction is to subsidize research—not only in the traditional university and research center settings but also within the private sector—aimed in the appropriate direction. Increasing funds (e.g., "Economy, Ecology en Technology" (EET), Programma voor Milieu en Technologie (ProMT, Program for Environment and Technology) are being made available for this purpose.

Beyond the subsidy of research, attention is turning to other policy instruments that might further these goals. These instruments are not only financial in nature (e.g., selective tax incentives), but also non-economic (e.g., government as a knowledge broker, government as opinion leader). Here, too, the Dutch government, through the actions of various ministries singly and in combination, has been active.

Investments in eco-efficient production may well lead to increases in the competitive edge currently enjoyed by the Netherlands, since efficiency in use of materials and energy may well lead to a cut in costs. Sharing of these experiences, as well as a further improvement of the "profit" by stimulation measures (e.g. adaptation of the tax system and increase of the taxation on energy use) have contributed to a growth of willingness in industry to invest.

This state of affairs is not only true in the Netherlands. Other industrialized nations as well as the European Union itself give a high priority to further research to better understand the possibilities of decoupling economic growth and environmental burden and to the development of measures to accomplish this decoupling. Since in our ever more global society, both the economy and the ecology are losing many if not most of the country border restrictions they may ever have had, the knowledge of sustainable production methods is by definition relevant on a global scale. It is therefore efficient

[1] Nota Milieu en Economie, Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Den Haag 1997.

from both the research perspective and the development perspective that different efforts to reduce the environmental burden be aware of and capitalize on the experiences of each other, even as countries compete to be the first or the best in this regard.

1.2. OBJECTIVES OF THE STUDY

Although the Netherlands is a leader in the effort to sustain both economic growth and the environment, it is highly appropriate for the Dutch government to look at measures taken by other governments to achieve the same objectives and, more generally, to encourage globally the mutual adoption of best practices. In the specific case of measures to encourage research by industry, this look is even more important, because the opportunities for innovative instruments can easily cross national and regional boundaries.

To help this ongoing search process, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM for its Dutch name), as the lead ministry among several interested in this process, asked RAND Europe to identify possibly interesting efforts in other countries that might be promising for the Netherlands. This report is the product of the resulting cross-country analysis of nine European Union Member States[2] and the United States. Our report contains five chapters, of which this introduction is the first. Chapter Two describes our approach and methodology, while Chapter Three provides a conceptual framework of potential roles and instruments that governments may use in stimulating research, technological development, and innovation in the private sector. Chapter Four gives a summary overview of the most important issues and findings organized by certain areas of interest, such as focus of the instrument, role of the government, and stage of innovation. The final chapter summarizes the conclusions drawn from the analysis and formulates recommendations to the Dutch government. A separate volume, containing nine individual country reports, presents detailed separate analyses of each country, used to formulate the results of Chapter Four and the conclusions of Chapter Five. These country reports all follow a similar format: a description of institutional context, a classification of the different policy instruments in use, and a detailed description of the most interesting initiatives. The initiatives were partially selected in order to span the important dimensions of policy in this area (public-private balance, financial v. non-financial tools, prescriptive v. responsive modes, general v. environmental focus). We further wanted to highlight initiatives that offered an interesting mix of strengths and weaknesses, in order to point the way to a mapping of issues and contexts to specific tools as opposed to a less-informative set of policies that represent 'best practice' because they happen to work in some setting and in some sense (usually defined by those with a vested interest in having the policy regarded as a success). Finally, we tried to mix initiatives that were unique to the countries' context but potentially applicable to the Netherlands with others that provided more direct points of comparison.

[2] Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden and the United Kingdom.

2. STUDY APPROACH

To organize this study, we first developed an analytic framework to structure it. We used this framework to guide a common analysis across nations. In consultation with the client, we selected ten countries for analysis and collected information through RAND Europe researchers or associates familiar with that country or subcontracted with partners familiar with the target countries. In this chapter, we describe in more detail each of these processes.

2.1. DEVELOPMENT OF ANALYTIC FRAMEWORK

To provide an accurate inventory, review and analysis of the experiences in the selected countries, it was important to have a clear analytic framework to classify initiatives, document and compare the outcomes and determine the factors that contributed to their success or failure. This framework enabled the researchers in all countries to pursue common types of information, thereby enabling the comparisons among countries we present in Chapter 4. More specifically, the framework served:

- To define what constituted the contextual factors that can influence the use of specific policy instruments to stimulate the private sector to develop, introduce and employ technologies that maintain or increase economic growth while maintaining or reducing the environmental burden of consumption;
- To get a way of describing the high-level approach taken by government in each of the countries surveyed and to assess the variety of roles, initiatives, instruments, etc. used in these countries; and
- To provide a guideline for the selection of the most interesting initiatives in each country.

These interesting initiatives, which provide the bulk of the information gathered, permitted a description of "behind-the-scene" information and enabled a comparative analysis that could identify the common characteristics and key differences among national initiatives and their outcomes. This ultimately provided analytic support for any recommendations of initiatives in other countries that are promising in the Dutch context. This framework, which we developed simultaneously with the choice of countries, is presented in Chapter 3.

We used the framework to determine the major questions that we would attempt to answer in this study. These were:

- What types of organizations are involved in the implementation of initiatives to develop innovation for sustainability? How do these organizations work?
- What factors contributed to success or failure of the initiatives?
- What specific contextual characteristics had an impact on the programs attempted?
- What developments in the implementation of certain programs have other countries experienced? Which of these provide lessons to be learned if similar programs are planned elsewhere?
- What methods for assessing the effects of programs are being applied in the respective countries?

2.2. CONDUCTING AN INTERNATIONAL ANALYSIS

It is important to understand the fundamental lessons of the experience of different countries for (changes in) the design of Dutch policies and mechanisms to stimulate sustainability-oriented innovations and knowledge development in the private sector. Government programs focused on sustainable innovation could have strong effects (intended or otherwise, positive or otherwise); these effects can be seen in a wide variety of social or policy areas, consumer roles, contractual forms, etc. The success or failure of particular initiatives reflects these specific factors and can assist in adapting the international experience to the evolving Dutch context. In addition, this is an extremely broad

area, and it is necessary to strictly limit the scope of the investigation to initiatives offering strong potential for success in the Dutch context.

However, it would be inappropriate to ignore the systematic differences among the countries studied here. These differences can both account for some of the variation in the practical implementation of innovation policy and have strong implications for the success of "technology transfer" from one country to another. There are several different ways in which information about other countries can contribute to the development of policy in the Netherlands.

- First, other countries may have had a different experience with innovation programs, resulting in different ways of defining the issues and meeting the challenges. In other words, they may provide new perspectives on the policy interconnections, and the reciprocal evolution of government policy, private activity and social objectives.
- Second, the pace of development might have been very different. The concept of a "National Innovation System" (further developed below) could help in understanding the pace and direction certain countries follow in stimulating sustainable innovation in industry.
- Third, other nations may have tried policies that have not yet been employed in the Netherlands. Conspicuous examples can be found in the selected countries. These can provide a source of practices to emulate or avoid.
- Fourth, the increasing international activity of global 'players' and supranational regulations and agreements makes the experience of key nations an important part of the Netherlands' policy environment.
- Fifth, the selected nations span a range of philosophies regarding the proper role of government and its interaction with private parties. This makes their experience relevant to understanding of the broader social issues referred to for the second phase of the requested work.
- Finally, the international comparison can provide an indication of important trends as well as a cross-sectional picture of different situations.

These considerations had to be taken into account not only in the development of the analytic framework but also in the selection of countries.

We used several criteria to select countries that could provide interesting comparison points and lessons to the Dutch situation. First of all, we wanted to include countries where sustainable development issues are differently perceived, presuming that this would lead to a different use of instruments and design of programs. Second, we sought countries where the investments in research and technology developments were of considerably different size. Third, we wanted to examine a range of countries with different national innovation systems and therefore different context characteristics. Finally, we did not wanted to omit larger European countries as they often proof to be leaders in the developments in a policy area. For each of these criteria, we wanted to make sure that countries that had similar characteristics as the Netherlands were included.

Applying these criteria, the following ten countries were selected for the survey: Austria, Belgium, Denmark, France, Finland, Germany, Italy, Sweden, United Kingdom and the United States.

2.3. COLLECTION OF DATA

The research was conducted by a consortium under the leadership of RAND Europe and consisted of Lisberg Consultants (Denmark), Prognos (Germany), Solving, Bohlin & Stromberg (Sweden), and Solving International (France, Italy), and the RAND offices in Leiden, the Netherlands and Washington, DC, United States.

The research project lasted from 1 January 2000 until 1 October 2000. Actual data collection took place between 1 February 2000 and 1 June 2000. Because of the diverse nature of the information to be collected and the importance of understanding national characteristics, we assembled an international team of researchers to collect data in the selected countries. To streamline these activities, we took a three step approach.

First, we organized a workshop to discuss the available background materials, determine research priorities, and finalize the development of the information collection tools and elaborate on the use of them. At this workshop, representatives of the project steering group attended and discussed the project with the international team.

Second, team members collected information about interesting initiatives by conducting desk research and conducting in-depth interviews. In a second workshop, results for each country were presented and discussed, and assessed on their completeness.

Third, based on the information and insights from the different countries, the RAND Europe researchers analyzed the lessons learned per country for their applicability to the Netherlands. A preliminary version of our conclusions was presented to the project guidance group, and that discussion was used to assist in the preparation of the present document.

3. THE ANALYTIC FRAMEWORK: ROLES, INSTRUMENTS, AND THEMES OF ATTENTION

This chapter provides the analytic framework we employed during this study. We first considered the institutional context of the study, including the institutional roles played by the different actors within national innovation systems and national systems for sustainability. Here we discuss the elements of National Innovation Systems (NIS) and a categorization we followed during this study

The consideration of NIS led to a discussion of the variety of roles that government can play within these systems. The implementation of the roles in policy instruments followed logically from a consideration of these roles.

Finally, we examined the themes that have experienced greatest attention in the Netherlands when looking at sustainability within the national innovation system.

3.1. THE INSTITUTIONAL CONTEXT

The position of government in the total national innovation system (NIS) has important implications for the role it assumes in stimulating innovation and for the instruments that it selects to achieve its objectives. The concept of an NIS is becoming increasingly familiar as the importance of links among science, technology, economics and public policy is recognized and 'linear' models of innovation give way to system-oriented approaches. Briefly, an NIS can be classified in terms of:

- *Institutional factors* - These include the educational infrastructure, financial markets (especially as regards technology risk), the research and development sector and the legal framework (especially with regard to intellectual property rights).
- *Public policy* - This includes direct RTD support of the forms considered here, indirect support through e.g. tax policy and targeting of support to particular fields, disciplines or institutions. It is here that one finds the interface between the NIS and the interest in sustainability.
- *Incentives* - This refers to economic factors such as local demand, factor prices, availability and quality, public and private investment, the nature and degree of economic and academic competition and the managerial and research cultures. These are important in considering the effect of alternative implementation plans for policy objectives.

Using an approach that links NIS structures (defined through 179 parameters) to macroeconomic structure and performance, Amable, Barré and Boyer (1997)[3] classified NISs into four groups, of which three are represented in our sample of countries.[4] Briefly, these groups and their defining characteristics are as follows:

- *The 'Market' system* - This group includes the UK and the US (as well as Canada and Australia). It is characterized by: scientific specialization in the life sciences; industrial orientation towards aerospace and pharmacology, globalizing firms; conventional technology management; flexible labor markets and RTD systems; an important higher education sector; and flexible, risk-tolerant financial markets.
- *The 'European Integration' system* - This group includes France, Germany, Italy and the Netherlands. It is characterized by scientific specialization in mathematics, physics and chemistry; industrial orientation towards machinery and chemicals; extensive public-sector participation in research and education; correlated macroeconomies (esp. with respect to growth and unemployment); and active public intervention in labor relations and social transfers.

---

[3] Amable, B. Barré, R. and Boyer, R. Les Systèmes d'innovation à l'ère de la globalisation, Economica, Paris, 1997.

[4] The fourth, '*meso-corporate' system*, is applied by Amable et al. only to Japan.

- *The 'Social-democrat' system* - This is represented by the Scandinavian countries. It is characterized by internationalized research; industrial orientation towards resource-intensive industries; rapid adoption of new techniques; high expenditures on education; and a relatively costly financial system.

3.2. ROLE OF GOVERNMENT IN STIMULATING INNOVATION

That government has an interest in stimulating innovation is nowadays taken as a given. The societal benefits, over and above knowledge as a pure public good include:

- promotion of the international competitiveness of domestic enterprises;
- capitalization on the external effects of innovation;
- mitigating financial constraints due to incompleteness or failure of capital markets - particularly by compensating for size- or risk-related difficulties; and
- strategic trade policy considerations.

There is a rich variety of possible roles that governments can fulfill in stimulating innovation in industry. A recent RAND study[5] grouped this variety of possible roles that governments can fulfill into three broad categories (government as a financier, stimulator, or facilitator), distinguishing several alternatives for each of these categories. Below, we adopt and expand upon their analysis. It is important to note that the three categories of government roles are not at all mutually exclusive; different government agencies can and often do adopt multiple roles.

3.2.1. Government as a financier of knowledge infrastructure

In general, it is believed that the government has the responsibility to invest in the basic infrastructure of education and knowledge generation for science and technology, particularly in universities and research institutes. The educational system in its entirety is a public good that provides industry a skilled work force, citizens employment, parents child care, and the public a cohesive society. In order to provide a skilled work force for R&D, there is a natural direct linkage between the amount of money given to universities and the number of graduates.[6] Furthermore, direct funding of university faculties directly influences the availability of future skills.

In many countries, companies are taking a more active role in investing in the basic training of people by providing funds for universities and technical schools. This is not only funding of research, but also funding of education, in the form of sponsored professorships or courses. This new involvement has a number of possible non-mutually exclusive interpretations. This investment could be a signal of slowness and lack of vision on part of government in responding to societal needs. It could also be a development resulting from increased competition for scarce skilled human resources. Within this interpretation, companies support education to increase the skill supply or to have a competitive advantage over other companies in hiring new graduates.

In addition to investing in the education and training system, governments also provide direct financial support for the development of processes and products. They use several modalities to allocate these monies over a diverse set of science and technology actors, both in the public and the private sector, to generate technological knowledge. There are many ways in which government can distribute money to stimulate technological development, including:

- Subsidizing targeted research and development (fully or partly) in the university and research institute sector;

---

[5] Popper, S., C. Wagner, E. Larson, New Forces at Work, RAND, Santa Monica, CA, 1998

[6] Here, we caution that university funding for educational purposes is directly linked to the size of the student population. Depending on its effect on the work of professors, additional research funding can direct the direction of students' studies, and can either expand or constrain the size of the student population.

- Subsidizing fully or partly research and development in the private sector;
- Tax write-offs for private investment in the "right kind" of R&D;
- Co-investment in R&D ventures.

In addition to financing the creation of knowledge, government has a role of financing physical infrastructure related to communication and knowledge dissemination.

3.2.2. Government as a leader, stimulator, and catalyst

Government has an important role in leading and stimulating the public discussion and acting as a catalyst to correct "system failures" – situations where a part of the innovation system does not function efficiently. The main challenge here is to recognize the parts of the innovation system where and what form of intervention is needed. The actions of government in these roles are numerous. Some categories of governments' functions include:

- creating social support in the industry by force of argument;
- stimulating public opinion and the demand for products;
- acting as a launching customer;
- resolving conflicts of interest;
- measuring and directing progress;
- providing strategic information to industry and citizens.

3.2.3. Government as a legal facilitator

Government creates laws and regulations with multiple intentions. In addition to controlling economic activities in a way that supports the general well-being of its citizens, government generally wishes to generate a favorable business environment. A sound legal and regulatory framework that supports such diverse goals:

- creates stability;
- sets standards; and
- provides a level playing field for business operations (e.g., intellectual property rights).

For example, government can make use of its legal framework to attract selectively foreign companies. Moreover, regulations may be used to prevent companies from actions that might harm society.

3.3. TECHNOLOGY POLICY INSTRUMENTS

Just as there are many roles that government can take in stimulating innovation, there are, for each role, various policy instruments that can be used to fulfill those roles. These instruments vary to the extent to which they exercise control over the conduct of research and development or the extent to which they competitively allocate the resources for R&D. The forms of support adopted by any individual country are strongly affected by historical, organizational and other factors.

Based on previous work and ongoing project activities, we have constructed a list of potential technology policy instruments that can be used by governments. This structure served as a checklist to identify and categorize initiatives in the selected countries. We have organized the presentation of different technology policy instruments around the roles of government discussed above. Different instruments are designed based on the understanding of what the role of government is and to what areas the instruments are targeted to as well as how they help to achieve the overall goals of the government. Table 1 presents these categories of different technology policy instruments presented in this study and provides examples of specific instruments.

Main category of instruments	Subcategory of instruments	Examples of types of instruments
Instruments financing knowledge infrastructure	Direct subsidies for selected actors	• Institutional funds • Program funds • Project funds • Build up physical infrastructure to support knowledge infrastructure
	Supply of capital	• Different types of loans given by government • Government as co-investor in a company • Public-privately owned research institutes
	Financial and economic incentives	• Loan guarantees (guarantee for bank loan, guarantee against losses) • Tax incentives
Instruments stimulating, leading, and catalyzing knowledge dissemination	Knowledge management and transfer instruments related to 1) Networking, 2) Human capital, and 3) Creating new business and supporting business operations	• Centers of excellence • Awards • Science parks • Information collection and dissemination • Consulting services • Networking instruments • Joint research centers with foreign governments • Encourage mobility of researchers • Encourage mobility of workforce
	Participatory instruments	• Mandatory "green procurement" • National procurement information centers • Government demonstration projects • Public-private partnerships (pilot projects)
Instruments facilitating the regulatory conduct of business related to knowledge development	Laws and regulations	• Environmental legislation • Taxation • Intellectual property rights
	Voluntary standards	• Emission trading schemes • Green labeling • Voluntary individual agreements • Performance standards • Environmental management systems

Table 3-1 -- Categories of technology policy instruments

These categories are not exclusive and as matter of fact are often used in combination within one specific program or initiative. It is also clear that even for performing knowledge management or regulatory functions, governments will have to provide financial contributions that could have an effect on the knowledge infrastructure. In the following sections, many of the examples provided in the table will be further explained and described.

3.4. THEMES OF ATTENTION IN THE NETHERLANDS

As already mentioned in the introduction, the Dutch government has promoted a shift in the attention of environmentally oriented technology policy. Several policy papers and programs have emphasized this issue. Where in earlier environmental policies, the focus was put on improvement of existing

technologies, current policies include redesign of current products and processes and the reconsideration of ways to fulfill certain needs.

Aided by an increase in the budget available for governmental activity in the area of environment, there has been a conscious increase in activities within the following themes:

- Improvement of existing products and processes;
- Redesign of products and processes;
- Function and system innovation;
- Market introduction.

Although the Dutch government is generally satisfied with its actions within these themes, it is interested in what other countries might be doing, and the possible adaptability of new policy instruments supporting these themes for the Netherlands. Indeed, it is this interest that was the primary impetus for the present project. Therefore, a distinct purpose of the project was to examine foreign initiatives within these themes.

4. RESULTS

In this chapter, we present the results of our investigation. We will begin with a short country by country summary of our findings. These summaries are based on a more thorough analysis of the situation of each of the countries that have taken place.

This summary will be followed by sections that discuss major topics of interests separately in a more cross-cutting analysis. These topics will focus on:

- The role of government in the NIS, and in particular the locus of responsibility for funding of technological innovation programs and environmental sustainability programs.
- The state of the national discussion on sustainable development. Different countries have reached different stages of "maturity" in this area.
- The use of the different categories of policy instruments (see Chapter 3) by different countries.

A separate volume to this report contains nine country reports that were included in the survey.

4.1. COUNTRY BY COUNTRY SUMMARY

For each of the countries surveyed, we will present in a single paragraph:

1. The population and land area of the country, to establish a context;
2. The degree of centrality of the country's National Innovation System, as well as its categorization according to the Amable et al. (1997) scheme;
3. The "maturity" of the country's policy to sustainable development (this is described more fully below);
4. The major projects within this country that we examined in detail (if any);
5. Any additional comments.

This section 4.1. is concluded by an overview table of the most interesting initiatives and some of their attributes that aim at stimulating innovation toward sustainable development per country.

4.1.1. Austria

Austria has a population of approximately 8 million and a land area of 83.855 square kilometers. Its NIS is perhaps best characterized as a European Integration system. Technological matters are centralized within the Ministry of Transport, Innovation and Technology, with the Ministry of Environment concerned with sustainability matters. However, implementation often takes place through intermediate agencies, public-private partnerships, and on a regional and small-scale level. Austria has a fairly well-developed concept of sustainable development, with a specific focus on sustainability within individual programs. Sustainability is not so much integrated in other policy domains. In our country examination of Austria, we examined the Austrian Program on Technologies for Sustainable Development, which examines energy, renewables and cleaner production on both the national and regional levels, and ECOProfit Graz, a program for market innovation. In Austria, the industrial perspective is important; thus, there is a focus (but not an exclusive one) on the implementation phase of technological development

4.1.2. Belgium

Belgium has a population of about 10,2 million and a land area of 30.510 square kilometers. Although its NIS is not very distinguished, it fits more closely to the European Integration system than to any other. Technology falls under the aegis of the Ministry of Science, Technology and Culture, although the decentralization of Belgium into highly overlapping regional (Flanders, Wallonia, Brussels) and cultural (Dutch, French, German) divisions means that there is a complex and

non-stable division of responsibilities on basic research and technological development between federal and lower levels of government. This process has been ongoing for over a decade and stability is not yet in sight. Sustainable development and innovation are only loosely tied, with the bond being most strongly developed in the Flemish/Dutch-speaking region. Local influences are stronger than national ones. No major national-level programs were identified, although some smaller national and slightly larger regional ones were identified and are discussed in the country report.

4.1.3. Denmark

Denmark has a population of approximately 5,3 million and a land area of 43.070 square kilometers. It has a Social-democrat NIS. The Danish NIS at the national level is centralized in the Ministry of Environment and Energy and the Ministry for Trade and Industry; however, these ministries can devolve much of their responsibilities to more local bodies. Denmark has a well-developed concept of sustainable development tied with an integrated policy approach: sustainable development as part of other policy domains. Political consensus to prioritize sustainable development. The international and (green) competitive position of Denmark in this respect is emphasized. In the service of sustainability, there is an increased use of market conforming and voluntary measures, with an emphasis on green labeling. In our country study, we looked at the Danish "Green Business Strategy," which brings the private sector, interest organizations and research institutes together, and the program of Re-coupling, or the integration of sustainability into a whole range of sector policies. As much as any country, Denmark has a reorientation from a single and traditional instrument approach (detailed regulation and control) used in the 1980s to a multiple and innovative instrument approach (economic incentives, knowledge dissemination, capital market development).

4.1.4. Finland

Finland has a population of about 5,1 million and a land area of 337.030 square kilometers. Its NIS is a mixture of the European Integration system and the Social-democrat system; the industrial focus on electronics and telecommunications moves it from the latter towards the former. Technology policy in Finland is highly centralized, with the Ministry of Trade and Industry having the primary responsibility. However, a lot of policy leeway is given to Tekes (the Finnish Technology Center), which is the chief implementer of technology policy. Tekes employs the full array of policies—not only funding and prioritizing, but also facilitating private-public partnerships. Finland has had a major focus on technology development resulting from its economic problems in the beginning of the 1990s. Thus, the main objective of the NIS is improving the economic and competitive position of Finnish industry. However, especially recently, environmental and sustainability issues are being incorporated into the NIS. The Ministry of Environment speaks for sustainability, and has a significant voice in its interactions with the Ministry of Trade and Industry and with Tekes. In our Finnish country study, we examined the Tekes technology programs aimed at sustainability, voluntary agreements, and the Environmental Cluster Program conducted by the Ministry of Environment.

4.1.5. France

France has a population of about 58,8 million and a land area of 547.030 square kilometers. Its NIS is European Integration. France is highly centralized, and the central government takes an interventionist role, although there is a slow trend toward more indirect stimulation. Still, however, there is very little interaction between the public and the private sectors. The Ministry of Education, Research and Technology has responsibility for support of technological innovation. France still has a rather traditional clean-up environmental policy; although there are a number of innovation efforts, their connection to sustainable development is lacking. Our country study most closely examined the ADEME program, which is an active effort to communicate issues in energy management and environmental policy to decision makers.

4.1.6. Germany

Germany has a population of approximately 82,1 million and a land area of 356.910 square kilometers. Its NIS is perhaps the prototypical European Integration one. The Federal Ministry of Science and Education and the Federal Ministry of Economic Affairs and Technology deal with matters of technological innovation, although perhaps the lion's share of the effort is conducted at the level of the *Länder*. The federal structure, together with the problems of reunification, have had a large influence on the organization and focus of the innovation landscape. As a result, the German economy is in structural flux; one of the more constant factors, though, is the dominant role of large companies in research and development. As would be expected from a country with the Green Party in power (although this orientation preceded their entry into government), Germany gives sustainable development high priority. There are large programs with specific foci. That said, the various sustainable development programs are not highly integrated. New initiatives in this regard include the innovative use of traditional instruments such as taxation and legislation, as well as financial support for public-private partnerships. Our country study looked in detail at the Research for the Environment program to support sustainable innovation in business and society, on a program to support innovation on plastic production and waste treatment, and on "green pricing" for energy.

4.1.7. Italy

Italy has a population of approximately 56,8 million in a land area of 301.230 square kilometers. Its NIS is the European Integration system. The Italian effort on technology development is coordinated by the Ministry of Industry, although it is highly decentralized. Italy has barely begun to grapple with issues of sustainable development. Because of the paucity of information we obtained in our examination of Italy (which is largely a result of a corresponding scarcity of information to be found), we did not find a program to examine in detail, and did not write a country study of Italy.

4.1.8. Sweden

Sweden has a population of approximately 8,9 million and a land area of 449.964 square kilometers. Its NIS is perhaps the prototypical Social-democrat system. In the highly decentralized government of Sweden, ministries do not play a strong role in the NIS; the non-ministerial agency NUTEK plays a central role, not only in the disbursement of funds, but in overseeing the various authorities. Sustainable development is highly mature in Sweden, being not only an issue of technological development, but encompassing many social and market-related activities as well. Our country study looked at the Delegation for Sustainable Technology, which acts as a catalyst for the market introduction of sustainability, and direct subsidies through NUTEK of environmental and energy technologies, and at local investment programs.

4.1.9. United Kingdom

The UK has a population of about 59,0 million and a land area of 244.820 square kilometers. Its NIS, more than any other European country, is the Market system. Although a strong movement towards devolving responsibilities to England, Scotland, Wales and Northern Ireland would lead one to consider the UK as a decentralized country, the current leadership has put forward a "modernising government" initiative that places heavy emphasis on "joined up government." This means not only inter-ministerial efforts, but also a focus on bridging private and public objectives, research and interests. In this joined-up approach, the Ministry of Trade and Industry, together with the Ministry of Environment, Transport and the Regions have the largest responsibilities of technology and innovation. Sustainability is not a central issue, although it has some priority when its economic benefits are manifest. "Greening government" initiatives aim at incorporating some sustainable development concerns in procurement activities and policies. There is also a change in the government approach to stimulating innovation, such that environmental issues become part of a bigger picture within cross-cutting policies. Our country study looked at the Foresight/Link extensive

exercise for promoting function innovation, at the EESOP program for improvement and redesign of standards, and at the ROPA program for funding basic research in sustainability.

4.1.10. United States

The US has a population of about 270,3 million and a land area of 9.629.091 square kilometers. Its NIS is the prototypical Market system. The United States has a highly decentralized NIS—no single Cabinet department (Ministry equivalent) has a strong role; the White House Office of Science and Technology Policy, on the other hand, does act as an information center and coordinating center. Government environmental and technological The relatively weak position of government is replaced by an important role for small and medium enterprises in technology innovation. Although sustainability per se does not figure significantly in American government efforts, there do exist a number of interesting programs in that regard. Many of them are not targeted specifically at sustainability, but include that as part of a more general effort at a broad innovation scope. In our country study, we looked at the ETV program for the market introduction of new technologies, the Industries of the Future initiative to improve and redesign basic research and technological development, and an initiative to act as a broker to bring venture capital and would-be technological innovators together. In the United States, market introduction initiatives are very much left to the market because of political sensitivity; public-private partnerships play an important role.

Table 4.1. on the following page gives an overview of the selected initiatives per country. The selection took place based on a number of considerations. The initiatives were partially selected in order to span the important dimensions of policy in this area (public-private balance, financial v. non-financial tools, prescriptive v. responsive modes, general v. environmental focus). We further wanted to highlight initiatives that offered an interesting mix of strengths and weaknesses, in order to point the way to a mapping of issues and contexts to specific tools as opposed to a less-informative set of policies that represent 'best practice' because they happen to work in some setting and in some sense (usually defined by those with a vested interest in having the policy regarded as a success). Finally, we tried to mix initiatives that were unique to the countries' context but potentially applicable to the Netherlands with others that provided more direct points of comparison.

Table 4.1 Summary of Initiatives Examined in Detail

Country	Highlighted Initiatives	Theme Focus	Instrument Used	Role of government	Stage of Innovation
Austria					
	ATSD	system innovation	direct subsidies	financier stimulator	basic research(/all)
	ECOProfit	market introduction system innovation	knowledge management: networking/create business	stimulator	implementation
Belgium					
	Ecologie Steun	improvement of exisiting products and processes	direct subsidies	financier	technological development
Denmark					
	Programme for cleaner products	market introduction system innovation	direct subsidies	stimulator	implementation
	Programme for energy efficiency	improvement and redesign	direct subsidies	financier	implementation
	Subsidy scheme CO2 taxes	improvement and redesign	financial/economic incentives	financier legal facilitator	implementation
Finland					
	Environmental Cluster Programme	improvement and redesign	direct subsidies knowledge man.:networking	leader	systems analysis
	Tekes Technology programme	system innovation	direct subsidies/supply of capital	financier	technological development
France					
	Ademe initiatives	improvement of exisiting products and processes	knowledge management: support business operations	stimulator	implementation
Germany					
	Solarthermic Technologies 2000	redesign of products and processes	direct subsidies	financier	pilot projects/tech. development
	ZOW	redesign of products and processes	direct subsidies	financier	implementation/tech. development
	Renewable Electricty Laws	improvement and redesign	legislation	legal facilitator	tech. development/ implementation
Italy					
	Environmental Legislation (IPPC)	pollution control	legislation	legal facilitator	---
Sweden					
	Delegation for Sustainable Technology	market introduction	knowledge management: support business operations	catalyst	implementation
	Environmental and Energy Technologies	function innovation	direct subsidies	financier	technological development
	Local Investment programmes	improvement and redesign	supply of capital	stimulator	technological development
United Kingdom					
	ROPA	function innovation	direct subsidies	financier	basic research
	Foresight/Link	function innovation	direct subsidies	financier	basic research
	EESOP	improvement and redesign	standards	legal facilitator	technological development
	Framework for Business	system innovation	legislation/standards	legal facilitator	technological development
United States					
	ETV program	market introduction	knowledge management: create business	catalyst	implementation
	Industries of the Future	improvement and redesign function and system innovation	direct subsidies/public-private partnership	financier	basic research/tech. development
	Venture Capital	market introduction	supply of capital	financier	pilot projects/tech. Development

4.2. THE ROLE OF GOVERNMENT IN THE NATIONAL INNOVATION SYSTEM

In our examination of ten different countries, we found ten different ways in which the government engages technology development, sustainability, and the private sector. These differences concern the intensity of investment in research and development, the locus of responsibility for technological innovation and sustainability matters, the role of government in the NIS (including private-public partnership), the centrality of governmental decisionmaking, and the concentration of focus of R&D efforts directed at technology for sustainable development. Throughout this chapter, we will illustrate our points by referring in "boxes" to initiatives studied in detail among the countries studied. Full descriptions of these initiatives may be found in the country reports.

4.2.1. Investment in Research and Development

The differences among the countries begin with the amount of investment in research and development (GERD) and the percentage of that investment that is undertaken by the private sector. Table 4.2 presents these figures for each of the countries, almost all for the year 1995:

Table 4.2 Investment in Research and Development

Country	GERD as percent of GDP	Percent of GERD in public sector
Austria	1,6	49
Belgium	1,5	30
Denmark	2,0	35
Finland	2,9	35
France	2,4	48
Germany	2,3	33
Italy	1,3	50
Sweden	3,8	25
United Kingdom	2,2	35
United States	2,8	32

Source: European Commission, Second European Report on Science and Technology Indicators, 1997.

The range in R&D investment runs from a low of 1,3 percent in Italy to a high of 3,8 percent in Sweden, while the percentage of that investment from the public sector ranged from a low of 25 percent in Sweden to a high of 50 percent in Italy. The amount of investment appears to be weakly related to the source of the investments, such that countries with a high percentage of investment from the public sector have a lower overall investment in GERD (correlation=-0.6). However, the low number of data points and the extreme positions of Sweden and Italy make generalization impossible. It is interesting to note in this regard that neither the absolute percentage of investment in R&D nor the role of government in that investment appear to relate to the distinctions made amongst NISs in the literature. Those distinctions would certainly suggest low public involvement by the UK and US and high public involvement by the Scandinavian countries, with the other continental European countries falling in the middle.

4.2.2. Locus of responsibility

In the Netherlands, the major locus of responsibility for policies regarding technological development is in the Ministry of Economic Affairs (EZ, for its Dutch title). However, VROM has a major voice in decisions regarding the environment, and specifically sustainability. Moreover, other ministries, including Education, Culture and Science (OCW), Transport and

Public Works (V&V), Agriculture, Nature and Fisheries (LNV), and of course Financial Affairs (FZ) participate. But the division of ministerial responsibilities in one country does not necessarily correspond to the division in other countries, so we examined these responsibilities for the ten countries of the study. The results are summarized in Table 4.3.

Four countries have ministries with technology in the title (Austria, Belgium, France and Germany); five countries link technological development with economic affairs or industry (Denmark, Finland, Germany, Italy and the UK); note that only Germany overlaps the two categories. Austria is the most highly focused country on innovation, with that term joined with technology in the ministerial title. Ministries concerned with the environment have formal voice in policies regarding technological innovation in three of the countries (Austria, Denmark, and UK); in the remaining countries, ministries responsible for the environment certainly are not silent, but are at some distance from programs for technological innovation.

Table 4.3 Ministerial Responsibility for Technology for Sustainable Development

Country	Responsibility for Technological Innovation
Austria	Transport, Innovation and Technology; Environment
Belgium	Science, Technology and Culture
Denmark	Environment and Energy; Industrial Affairs
Finland	Trade and Industry; Environment
France	Education, Research, and Technology
Germany	Science and Education; Economic Affairs and Technology
Italy	Industry
Sweden	(Ministries are weak) NUTEK acts as a coordinating center
United Kingdom	Environment, Transport and the Regions; Trade and Industry
United States	(no Department has primary authority) White House Office of Science and Technology Policy

4.2.3. Role of Government in the National Innovation System

We categorized each country examined on three dimensions related to its role in the NIS: (1) the degree to which decisionmaking was centralized in the national government, (2) the degree to which decisions regarding technological innovation were concentrated in single bodies or dispersed (without regard to whether these bodies were part of the national government) and (3) the degree of public-private partnership for programs supporting technology for sustainable development. In addition, we assessed (4) the extent to which each of the countries had a "mature" policy towards sustainable development, which we roughly defined as explicit acknowledgment and support for reversing or at least reducing the environmental burden of economic growth (vs. cleaning up the damage caused by economic growth). For the respective categories of centralization, concentration, public-private coordination and maturity, respectively, we recognized three rank-ordered classes, as shown in Table 4.4.

There are obviously clear differences in the roles that governments and industries play regarding the stimulation of innovation and sustainable development in the surveyed countries; note that no two countries have the same classification pattern. At one extreme stands Finland: centralized, coordinated, with a high degree of public-private partnership and a high maturity level for sustainability. At the other extreme is the United States, decentralized, diffuse, with little official public-private partnership and societally not a high maturity level. For a large extent these differences are due to different philosophies on the role of government in society as a whole. These philosophies can evolve over time but are also inherent in the specific characteristics of a country. Government in the United States has for instance a distinctive "hands-off" attitude, especially given the recent Republican dominance of Congress, while in Finland, government is viewed as a close partner of the main national interests, including industrial growth and environmental protection.

Table 4.4 Ministerial Responsibility for Technology for Sustainable Development

Country	Centrali-zation	Concen-tration	Public-private	Maturity
Austria	-	+	+	+
Belgium	-	o	-	-
Denmark	+	-	+	+
Finland	+	+	+	+
France	+	+	-	-
Germany	-	+	o	+
Italy	-	-	o	-
Sweden	-	-	o	+
United Kingdom	o[a]	-	+	o
United States	-	-	-	o

Note a: A philosophy of devolution in the UK would lead to a rating of "-"; however this is countered by the centralization of the Modernising Government program.

In addition, in recent years governments have initiated activities to modernize their organization and their way of acting in society in all fields. In some countries these activities have clearly progressed much further or earlier than in other countries. For instance, the "Modernising Government" agenda in the United Kingdom, an effort under the leadership of the Cabinet Office, aims at the "delivery of high quality public services designed to meet the needs and expectations of users, making best use of quality tools and new technology to increase flexibility, accessibility and standards," and to design "policy around shared goals and carefully defined results, not around organisational structures or existing functions." Similarly, governments in the United States and Sweden have followed similar agendas, although sometimes with very different results. The focus of these activities is the integration of policies, flexibility and adaptability to changing circumstances, and a more citizen/customer-oriented approach.

These developments of integration, decentralization and (public) information provision have had and will continue to have major effects on the organization of initiatives in the domain of sustainable development—given of course a country's decision to pursue sustainability—and possibly on the substance of the program. For example, stimulating interaction among different players and disseminating knowledge to achieve innovation has become much more prominent.

These developments and philosophies have had their effect in the use of instruments but also in the type of organizations that are involved in stimulating innovation in industry. Consider, for example, the public-private partnership program in the United States called "Industries of the Future." To understand this program, one must understand that there is a strong anti-trust legislation in the United States that provides limitations to the extent to which private

industries can work together in the development and promotion of products. Moreover, the present political climate makes government intervention, either in the form of regulation or guidance, difficult. Therefore, the Industries of the Future program focuses its attention to technology at very early phases of development, long before potential products for the market reach the design stage. Given the globalization issues described above and the increasing role of the European Commission in competition law, this could become an increasingly prominent issue for many governments.

Finally, globalization issues in industry have had their effect on priority setting in government and the way in which governments organize their support. Large companies increasingly operate internationally. They have extensive networks and they globally search for best places for different operations (head offices, R&D, production, marketing). Large companies can easily move their operations to where the required knowledge is. Thus, governments especially aim at keeping basic R&D activities of large companies in a country by having the required knowledge in a country. For example, many countries use instruments to attract skilled workforce from other countries to strengthen their local knowledge base. The underlying thinking to keep R&D of large companies in a country is that these activities create innovation of which some will spill over to start new companies and eventually create economic activity and work. One reasoning to emphasize the support of basic research and technology development in large companies is that they have well functioning operations further down the chain of technology development and the government support is not needed or even appropriate in a competitive situation.

UNITED STATES: INDUSTRIES OF THE FUTURE PROGRAM

The purpose of the Industries of the Future Program (IOF) is to improve the energy efficiency, environmental performance and productivity of energy-intensive industries through technology innovation. Federal and state R&D policy makers began to recognize that much of the expertise and decision making regarding the commercial viability of new technologies resides in industry. Therefore, policymakers began to explore ways to improve the cooperation between government and industry in the hopes of improving the likelihood that public R&D investments will generate commercially viable technologies that contribute to broad social goals such as economic well-being and environmental improvement.

The IOF program is a public-private partnership. IOF co-funds precompetitive R&D with the nine energy intensive (and waste generating) industrial sectors. The specific investments are determined using input provided by the industrial sectors. Each sector creates its own long-term (20-25 year) vision of desired industrial performance. Technology roadmaps identify the technological options and research and development needs to move from today to the industry outlined in the vision. The industrial sectors are responsible for the development and content of these visions and roadmaps but IOF facilitates their creation. IOF uses the visions and roadmaps to justify the program plan and to help determine what research projects it should fund.

The program is entirely **voluntary** and any potential investments required to accomplish the goals ultimately will be evaluated in light of energy prices, individual companies' financial status and general market conditions.

The primary policy mechanism used by the IOF program is **competitively awarded**, cost-shared R&D support for **precompetitive research** and development. Because of its organizational domain, OIT also targets funding to process and not end-use technologies. Technical assistance and information dissemination are also used in the program. The program's activities are designed to seek improvement of existing products and processes, redesign of products and processes, function and system innovation. Market introduction is left to the private sector.

Most of these processes involve active participation and coordination by the trade associations. In order to be funded by the IOF program a project must meet the following criteria:

- reduce energy use,
- minimize environmental impacts,
- improve productivity,
- involve pre-competitive research, and
- be process oriented (as opposed to end-use or product oriented).

The dynamics of the economic and industrial structures have probably even been more enormous and are probably felt in most countries. We can identify two main developments that are important to the stimulation of innovation industry that are caused by globalization and the need for networking, and the speed of technological development. The first development is the surge of new industrial areas that might perhaps have less environmentally negative side effects, such as information systems, bio- and nanotechnology.

FINLAND: TEKES TECHNOLOGY PROGRAM

The National Technology Agency (Tekes) has the main coordination and implementation responsibilities of directing R&D funds to industry. In 1998, Tekes distributed around 90% of public R&D money to industry. Since its foundation in the beginning of the 1980s, Tekes has steadily increased its role and has established a good reputation as an objective government organization supporting Finnish industry. Its mission is to promote the competitiveness of Finnish industry through the use of technological means. It incorporates the wider objectives of the well-being of the society as a whole by incorporating issues such as environment and health.

Technology programs have been the principal way for Tekes to stimulate technology development. The role of these programs has increased over the years. In the year 2000, Tekes has approximately 60 on-going programs with a total budget of Euro 1.3 billion. The main Tekes principle in supporting environmental technology development and environmentally friendly business practices is by not isolating it from other technology development. The Technology program provides horizontal support and targets specific environmental programs that use approximately 20% of the funds. Tekes prepares these programs, a process that could take up to several years.

Second, although connected to the first development, are changes in the importance of the different players in technological development. While in the United States the role of SMEs as an innovator has been very important for a long time, that role has been assumed by large enterprises in the European countries in this survey. SMEs in Europe often lacked the (risk capital) resources to take on that role or were often dependent on their relations with large enterprises. There is now growing recognition that SMEs can play an important innovative role. Instruments targeted to SMEs generally cover a wide range of phases of technology development because support is needed also during early phases of technology development to get resources for development work and to create networks for operations.

Dynamics of the industry development today set serious challenges to government organizations. Government organizations need to respond swiftly, monitor developments in other countries, and have the ability to restructure programs promptly. They also influence changes in the target groups (e.g., the shift to SMEs mentioned above) that should receive support. To accomplish all of this, for some, calls for a centralized approach.

A distinctly centralized approach is exemplified by Tekes, the national technology agency of Finland. Tekes is the embodiment of a top-down approach, focuses on knowledge needs within the central government sector, and has much larger component to research institutes.

4.3. STATE OF NATIONAL DISCUSSION ON SUSTAINABLE DEVELOPMENT

Environmental values and policies have long been a marginal factor in the national policies. Until recent years, technology policies have tended to focus only on the economic competitiveness of the nations. However, there seems to be an on-going shift in thinking in many countries from technology driven R&D policies based on competitiveness to integrated systems oriented to social needs and joint production of knowledge, goods, services and public welfare. The policy goals related to stimulating innovation are no longer uniquely expressed in terms of competitiveness and economic growth. Nowadays, sustainable development as a concept is linked with the broadening of the goals of technology policy from pure economic growth toward wider social and ecological goals. However, the degree to which this concept is operationalized is different among the countries we examined.

In the beginning of the seventies, several countries started to emphasis more intensively some of the negative side effects, primarily increased emissions, that were caused by economic growth. Standards were set and support was directed toward end-of-pipe technologies and waste management. The principal policy instruments to promote these developments were

regulation and restriction of activities and the reduction of energy use. This set up an "economy vs. environment" conflict that placed concern with the environment with the left side of the political spectrum (social welfare, regulation) as against the private sector on the right (economic growth, market forces).

In a number of countries, this conflict has been resolved by a paradigm shift that places environmental sustainability together with economic growth. The key to this shift is a conceptual decoupling of the environmental damage thought of concomitant with economic expansion, so that the environmental burden of economic well being is reversed—or at least slowed down. Technological innovation plays a major role in the achievement of this decoupling, as the forces of science and technology are redirected to sustainability—largely defined in terms of the Brundtland statement of offering our descendants the same environment we have now.

The shift is manifested in a change whereby the thinking of innovation and technology development as a "pipeline", in which a specific incentive leads to a specific effect, is abandoned in favor of a view that the process of creating new knowledge and technology is a result of complex interactions among actors that together form the national innovation system (NIS) as described above. The extent to which a country has adopted this perspective of course has significant implications for the priorities that a government sets itself, the objectives it tries to achieve, and the areas and themes to which it provides support. Different countries are at different stages of this development, as indicated by the last column of Table 4.4, presented above.

A paradigm shift presents a challenge for the operations of governmental agencies implementing technology policies. In many countries, new agencies have emerged or old agencies have changed to have a more focused mission merging technological and environmental thinking. For example, such agencies promote technological means for saving energy and protecting the environment as well as creating new business around these technologies. Such a broadening of goals further increases the need to understand which parts of a NIS should be active participants in the implementation effort and what types of instruments are needed to support and stimulate their functioning.

To summarize, the maturity of the discussion about sustainable development reflects two issues:

1) a paradigm shift in the specific area of sustainable development policy from a pure technological innovation approach to system innovation and broadening of goals, and
2) an acknowledgment of the complexity of the issue which has lead to a realization that different types of activities and cooperation among government agencies are required to affect a very dynamic and complex innovation system.

The Delegation for Sustainable Technology in Sweden (see framed information) is a good example of the paradigm shift.

SWEDEN: THE DELEGATION FOR SUSTAINABLE TECHNOLOGY

The Delegation for Sustainable Technology was appointed in September 1996. It is formally an Agency of Government, with delegated power to take decisions to spend taxpayers´ money. The Delegation comprises a committee of industrialists and public servants with a record of interests and capability in environmental issues.

The program was assigned the task of stimulating the development and facilitating the procurement and introduction of environmentally sound products, processes, and technologies designed to be compatible with ecologically sustainable development. The measures taken by the Commission will increase the competitiveness of Swedish industry and thus create new employment. The overall objective of the Delegation was defined in this strategy as to "Contribute to sustainable development of society".

One of the Delegation´s main tasks is to find methods facilitating and accelerating the marketing of new environmentally sound technology and testing methods. The commission therefore focuses on the demand side. Much of its work is devoted to formulating, together with users of various products and technologies, the functional requirements that should be met by environmentally sound products. It also analyses the potential environmental gains. In this spirit of experiment the Commission uses a range of different tools and project types to broker relationships between demand and supply.

The Delegation would pursue the following goals:

- Stimulating the commercialization of products, processes and systems which resolve significant environmental problems.
- Reducing the "time to market" for environmentally adapted products, processes and systems
- Increasing the sales of environmentally adapted products, processes and systems
- Raising the competitiveness of Swedish industry, and thereby increasing employment.

It is attractive but inaccurate to think of the shift in the relationship of environment and economic growth as leading to a shift in the types of instrument used for environmental policies. Concomitant with the paradigm shift, many countries are using economic instruments to a greater extent than more traditional forms of instruments. This might have been observed by a correlation between (de)centralization and maturity in Table 4.4. However, such a correlation is not present. This is further illuminated by Figure 4.1, which shows that countries that are front runners in thinking about sustainable development have adopted quite varied organizational structures. The basic message from this figure that certain organizational structures cannot necessarily be associated with a more developed sustainable development discussion or vice versa. Although all the most mature countries emphasize the importance of activities and cooperation among government players (that is, in Table 4.4, countries high on "maturity" are not low on "public-private partnership"), they have used both centralized and decentralized strategies, as well as concentrated and diffused ones, for implementation. The real paradigm shift is not typified by the choice of a specific category of instrument but rather by a combination of these categories with a different use of the regulatory role and an integration of economic (competitiveness), environmental (green business), and innovation objectives.

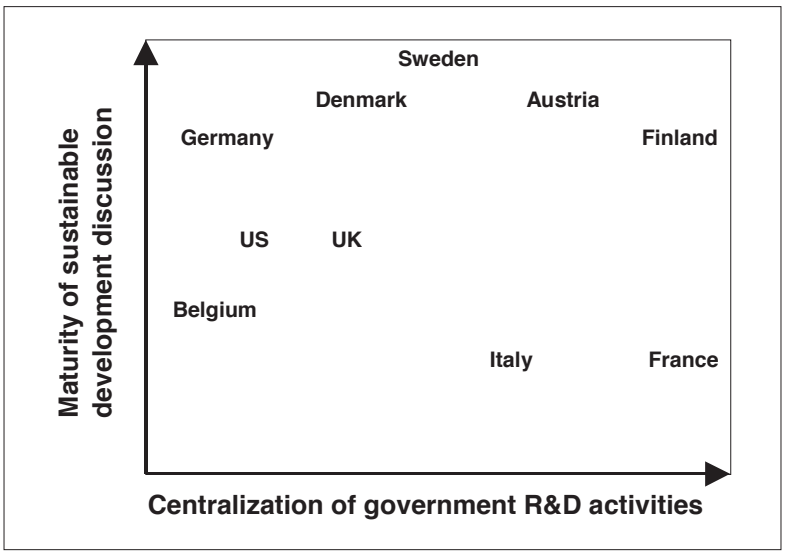

Figure 4.1 – The maturity of sustainable development discussion and the degree of centralization of government activities in ten countries

As the figure indicates, Italy, Belgium, France are, each for different reasons, not far along in adopting the sustainability paradigm shift. Yet these countries span the range of centralization. Their policies are characterized by fairly traditional policy instruments (emphasis on regulation rather than economic incentives), little movement beyond financial instruments, and not much linkage between sustainable development and innovation.

Another case is shown by the UK and the US, where large overall reforms of government operations and far-reaching economic restructuring has led to the use of a wider variety of policy instruments (albeit different in the two countries). But this restructuring has not associated with a mature sustainability perspective.

In Germany and Austria, there is a well-developed debate and an understanding of sustainability, but reform of the government is in early stages. Policy instruments are used in a modern way to promote sustainability, and “clever” ways of financing are experimented with. It is interesting to note in this regard that the "green" political party is part of the government in Germany, but not in Austria.

Finally, the Scandinavian countries all use modern policy instruments to attempt to implement a mature view towards sustainability, but differ significantly on centralization and concentration.

4.4. THE USE OF DIFFERENT POLICY INSTRUMENT CATEGORIES

This section will analyze the several instruments that different governments use, following the categorization of roles and instruments as presented in chapter 3. We present here our overall analysis that has resulted from the examination of the situation and initiatives across the surveyed countries complemented by the existing expertise of the project team members. To illustrate this analysis we have provided descriptions of specific examples of surveyed initiatives. In other instances we will either refer to the specific text of the country reports or to countries in more general terms.

4.4.1. Instruments financing knowledge infrastructure

As indicated in section 3.2.1. the general perception is that governments have a responsibility to invest in the basic infrastructure of education and knowledge generation for science and

technology, particularly in universities and research institutes. We distinguished several ways in which this can take place. For each of the distinct categories, we provide here an overview of how governments invest and what developments are influencing the implementation.

Subsidies

Direct program or project grants given to industry are a very common instrument used in most countries in some form. Direct subsidies can be given either in a reactive or a pro-active way. Reactive subsidies are given in those cases in which a certain need in a company emerges and both the company and the project needs fulfill a minimum set of criteria set by the government (e.g., only projects of local SMEs will be supported). Subsidies are given in a more proactive way when there is a clear vision of the instrumental goals and when candidate companies and their needs are actively sought for by the government. This type of proactive subsidies are usually organized around programs and are combined with a variety of knowledge management and knowledge transfer instruments. Generally, countries are moving towards a more proactive way in providing subsidies as their goals get more focused. The Austrian ATSD program is an example of this development in program design.

AUSTRIAN PROGRAM ON TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

Austrian Program on Technologies for Sustainable Development (ATSD) is initiated and sponsored by the Austrian Ministry for Science and Transport (BMWV). Program focuses on efficient energy use and renewables, cleaner production and products, and sustainable regional development. The program started in 1999 and will last until 2003 (about 3.6 million EURO per year). ATSD is targeted to improving existing products and processes, redesigning of products and system innovation as well as market introduction.

During 90's, many programs supporting R&D on **specific technologies** for a more sustainable development were implemented in Austria. However, a need for a **more holistic** approach supporting sustainable development arose in 1997. Also, additional funds came available for selected ministries. Because of the rather small budget which could be issued per year (3.6 million EURO), the Ministry for Science and Transport chose to sponsor only very carefully selected projects. In order to get ideas for the design of ATSD, the previous government program supporting innovative energy technologies was evaluated thoroughly. The main findings relevant for the design of ATSD were:

- The target area of support should be defined in a very specific manner, but not focusing on a certain technology alone. Any technical or non-technical approach that can be seen useful in reaching the goals set for the program should be acceptable. The broadening of activities beyond technical solutions gives more incentives for cooperation and the program responds better to the needs in the companies.
- The greatest effects in the previous programs (for applied research, pilot projects, and implementation of innovative technologies) were observed in small enterprises.
- Sustainable innovation needs complex innovation strategies. Experience from previous program showed that most of the companies are not able to design such strategies themselves. To help companies, it is necessary to provide information to increase awareness and to assist them in designing strategies towards sustainable innovation. Therefore so-called "active guidance" and "active strategy development" instruments are implemented within ATSD.
- Successful implementation and diffusion of R&D results on a broad level is only possible if a great number of actors is involved. To fulfill these goals all main actors involved (Ministry for Science and Transport, project managing company Technology Impulse ltd. and Austrian Energy Agency) systematically inform the broader public about ATSD.

It took 2 years to design a rather holistic concept of ATSD consisting of subsidies for R&D projects at research institutes and private companies for projects at different levels as well as supporting and communication activities. A special emphasis is put on communication. It was decided that the most efficient way to manage the program and to take care of communication is done through professional project management organization. ATSD is managed by the private enterprise Technology Impulse ltd.

The main incentives for companies to apply for public funds to build up their knowledge infrastructure are:

- Lack of capital
- Need to share the risk.

Despite these incentives, a company may reject the idea of applying for government funds if the costs of applying or the control mechanisms of the government outweigh the benefits or when other funds are more easily accessible and available. The availability of government funds is often associated with either complex administrative procedures, requirements with respect to co-financing or restrictions in exploiting the ownership of certain products or results. In several countries, we have found examples where specific government programs have difficulties disseminating the available funds and reaching the original target groups.

Venture Capital

Generally, the availability of capital is one of the main factors affecting of attractiveness of the country in international competition. Direct subsidies are usually given on project basis and other government instruments are used to provide a venture capital for companies. The venture capital instruments a government might use can be classified as follows (OECD, 1997):

- **Government equity investment** to make direct investments in venture capital firms or small firms (examples: fully government owned funds or hybrid public-privately owned funds, funds targeted at specific technology areas)
- **Government loans** to make low-interest, long-term and/or non-refundable loans to venture capital firms or small firms to take part of the risks (Tekes has its loan instrument that belongs to this category).
- **Tax incentives** to provide tax advantages, particularly tax credits, for example, to those investing in small firms or venture capital funds (for example, government could start a venture capital fund to which capital would be collected from citizens. Profit from the fund would be tax-free). For another example, see the Co2 program in Denmark on the following page.
- **Loan guarantees** to guarantee a proportion of bank loans to qualified small businesses (most widely used government instrument to help companies to get venture capital)
- **Equity guarantees** to guarantee a proportion of the losses of high-risk venture capital investments

In the United States we found the biggest variety of venture capital arrangements that were organized by government institutions. These venture capital programs basically followed two models. In the first, government actually provides venture capital to firms (often SMEs) for technology development. The selection of these firms or projects is done by applying fairly straightforward economic criteria (e.g., jobs created, potential economic impact, and rate of return). In addition, other government programs also provide other services, such as business plan development assistance and facilitating the handshake between technology developers and suppliers of venture capital (see also section 4.4.2. for a more explicit discussion of these types of instruments). However, none of these programs focus uniquely on innovation geared toward sustainable development.

Tax incentives

Since 1981, most OECD countries have moved away from direct R&D support to private companies to more varying tax incentives (OECD, 1999). In most cases, taxation instruments have more goals than just the supply of capital or the promotion of sustainable development. These kinds of instruments can be designed in ways that can influence company actions on R&D issues in various ways. Taxation instruments include (OECD, 1996):

DENMARK: CO_2 PROGRAM

The subsidy scheme is an integrated part of the introduction of the green tax reform in Denmark in 1994. The program has an allocation Eur 250 million from 1999-2003. The program aims to

- promote energy efficiency in energy intensive enterprises
- secure that energy intensive enterprises under competition are not burdened by green taxes to a extent that significantly reduces their competitiveness.

The program is based on the idea of earmarked redirection of green tax revenue to the enterprises with high tax-incident/costs that are not transferable to consumers.

The signing of an energy efficiency agreement is a precondition for the subsidy. By an agreement between the enterprises and the Energy Agency the enterprises commit to carry out a number of energy saving measures and to introduce energy management. In return the Energy Agency grant a subsidy for reduction in the CO2 tax put on the enterprise. The agreements run for 3 years at the maximum. During the agreement energy audits are carried out by an independent verifier and reporting to the Energy Agency are made.

Project are approved and selected by the Energy Agency. The enterprises have to:

- make energy audits, energy management reports and actions plans
- carry out the agreed activities
- implement energy management
- report to the Energy Agency

Assessment of effectiveness is done on the basis of the general guidelines for subsidy schemes from the Ministry of Finance and National Auditors. Moreover, the agreements are monitored through energy audits performed by independent verifiers and reports to the Energy Agency on results and progress.

- R&D depreciation rate – in most OECD countries, all non-capital R&D (e.g., labor costs, energy use) expenditures (100%) can be deducted from taxable income in the year in which they are incurred.
- R&D capital depreciation rate – the rate at which R&D related equipment and building costs can be depreciated in taxation. With this respect there is a great variation among the countries.
- The number of years over which R&D expenditures can be amortized and tax deductions can be carried forward. The purpose of the instrument is to give the same benefits for different types of industries independently of temporary losses or cyclic changes.
- R&D tax credits based on different rules. For example, the Danish example provided above, firms can get a tax credit if they are able to introduce energy saving measures and management.

The effects of direct R&D support compared to taxation instruments are not always clear, but it is generally understood that both instruments (and all variations on these two instruments) affect the level of R&D investments in companies. R&D tax schemes seem to have some advantages of being easier to control for the government and a more stable instrument for the company than direct R&D support.

Physical Infrastructure

In creating the knowledge infrastructure, it is traditionally the responsibility of the government to provide the physical infrastructure (guarantee of road infrastructure, communication services in affordable prices etc.). However, technological alternatives for physical infrastructure in order to transfer information are changing rapidly. In companies, there are new types of needs for so called *infratechnologies*, which refers to all communication infrastructure related technologies, but also to generic technologies and information such as test methods, common databases etc.

Some new types of government instruments are targeted to improve access to infratechnologies to all. For example, in many countries, national goals are formulated in order to get access to information networks for all citizens (e.g., Sweden, France, and U.S.). The improved access to infratechnologies can also be targeted to support, for example, SMEs or to attract companies to locate their activities close to universities. The government's role in providing targeted infratechnologies is closely linked with instruments related to knowledge management and transfer.

Other factors influencing financing modalities

Instruments targeted at universities and research institutes

While instruments targeted at stimulating innovation in industry through the public sector falls somewhat out of the scope of this study, one should note that the border between private and public research performers is nowadays often unclear and many of the instruments in this subsection could apply to private companies as well. For example, in Austria, certain

UNITED KINGDOM: THE LINK PROGRAM

The LINK scheme is the main initiative for promoting pre-competitive partnerships between industry and the research base, and is oriented towards innovation, wealth creation and (importantly for this survey) quality of life. The priorities are identified by the Foresight Programme, which is a large, ongoing (since 1994), Delphi-based technology foresight program. The results are used by companies of all sizes, and the process itself has broken down barriers to collaboration and focused research and industrial activity on quality-of-life issues. The results are also used across a range of government spending and policy decisions. Foresight is also administered by OST.

LINK research is typically well ahead of the market but potentially viable. Participation is open to any UK company and research institution, with an emphasis on SMEs. Currently, there are over 1700 industrial participants (more than 50% SME) and 200 research base partners. Multinationals can participate if they have significant UK presence and will exploit the results of research in the European Economic Area. LINK consists of several (currently 63) programs defined by technologies or market sectors, sponsored by Departments and/or Research Councils. All projects must involve collaboration. Overall goals are defined by sponsors in collaboration with industry and the research base, and each program further supports networks of interested parties. Projects last 2-3 years and involve specific management structures and agreements as to how fruits will be shared.

Sponsoring bodies include DTI, DETR, Department of Health, Ministry of Agriculture, Fisheries and Food, the Ministry of Defence and 5 of the 6 research councils. The main program categories are: i) electronics/communications/IT; ii) food/agriculture; iii) biosciences/medical; iv) materials/chemicals; and v) energy/engineering. Environmentally related activities have been funded under all of these

The initiative emerged during the Major government as a way of exploiting the widely admired results of the Foresight program while at the same time addressing specific industrial policy issues. These included the 'brain drain,' dwindling private support for research in the research base, a history of foreign exploitation of basic research developed in publicly-funded establishments, and in particular a set of poor results on investment in innovation by UK businesses. In addition, it was felt that particular areas of social or public concern were underdeveloped as regards innovation.

Each program is managed by a Programme Management Committee, which selects projects via a two-stage process (outline, then full proposal) informed by peer review. The 1100 projects currently underway or completed have a value of some £530 Million, and the government spends £37 Million annually. Public funding is made available on a 50% basis, with the rest coming from industry and is based on direct costs and other factors such as licensing. Selected projects must satisfy a list of specific criteria, including match with a sponsor's priorities, collaboration, innovation, synergy and the ability to catalyze something that would not happen otherwise.

institutes have been classified as public in certain years and as private in other years depending on their source of income. Government has a traditional role in supporting basic research infrastructure and education system. These roles will remain, but in addition several other types of instruments are introduced in different countries. An underlying motivation is to strengthen the knowledge transfer to industry and to be more responsive to the needs in industry with respect to skilled work force.

R&D performers operate in a global environment

For all instruments that are introduced mainly to provide capital for companies to operate or for universities and research institutes to use to create knowledge, there is an increased concern over the fact that users of money operate in a global environment (see e.g., Wagner 1999). Countries have different philosophies and rules on how to control this issue depending on their overall goals related to globalization. In most countries, clear playing rules over the issue are missing especially in those situations where:

- R&D projects (either in companies, in universities or research institutes or a combination of these performers) are completed in cooperation with foreign partners and the results are shared.
- A company wants to outsource the whole project from a foreign company.
- A company has R&D units abroad with foreign staff but production home.
- A company has a R&D unit home but production abroad where the results of the technology project will be implemented.
- A company is owned by foreigners but has R&D and production in a country with local staff
- A foreign company has only R&D or only production in a country but wants to start a project involving both units.

4.4.2. Instruments stimulating, leading, and catalyzing knowledge development

In this section, categories of instruments stimulating the technology development are discussed. Following the structure of the table in 3.2. , this section covers instruments targeted at knowledge management and transfer on the one hand and participatory instruments where government participates more actively in the technology development itself on the other.

Knowledge management and transfer

We have distinguished several categories of instruments targeted at knowledge management and transfer: i) networking, ii) human capital, and iii) market entry and business support related instruments. These instruments often do not have the explicit aim to develop innovation toward sustainable development, but are typical methods that stimulate and catalyze this development in indirect manners.

Networking

Networking is an integral part of business operations and a goal of many instruments. Governments increasingly realize that they can play a role of a facilitator providing a neutral platform for actors to interact and offering matching services to find the right partners to interact with.

Clusters are defined to be networks of different actors in the NIS producing and using knowledge. They consist of companies that act as customers and suppliers of technology and research units producing basic knowledge. There are a variety of possible clusters (e.g., a technology supplier and its client form a simple cluster). Most often clusters evolve on their own through company operations and interactions without government intervention.

However, a question from a government point of view is that what types of actions should be taken a) to create new viable clusters in new industry sectors and b) to support knowledge management and transfer within existing clusters.

We have observed that it is difficult to create new clusters. Some actions to create new companies are based on the concept of clustering by providing opportunities for interaction by means of proximity. Silicon Valley is perhaps the most famous example that encourages governments to try this type of instruments to repeat the success[7]. Instruments to start up "science parks" or "technology centers" also have a primary goal in knowledge transfer by stimulating the interaction between companies and universities. Most often the centers are established in university campus areas. In many countries, the such designated areas for businesses are linked to the goals of regional development but here are certainly examples of parks focused on more concentrated issues such as sustainable development. Another set of instruments that aim at increased networking use an idea of encouraging/forcing dialogue among companies or between private and public sector by other means than physical proximity, e.g., with conditional funding of projects. Examples of different instruments supporting networking include:

- Technology incubators: a company providing facilities for companies, office space, laboratories, consulting services, etc. Very often government owns part of the incubator that operates as a private company. Venture capital companies and organizations also often have an ownership over technology incubators.
- Public-privately owned research centers that are located in the proximity of universities and focus to solve problems of industry (For example, "competence centers" of Sweden are such 50-50 government –privately owned applied research focused institutes). These centers are also natural channels for researchers to work with more applied problems.
- Regional instruments to strengthen the capabilities of SMEs in a region by networking (i.e., not necessarily focused on one industrial sector) (see an example of the Austrian ECOPROFIT - Graz instrument below).
- Technology programs usually involve elements to enforce networking: 1) grants are given only if projects involve suitable partners (For example, universities need to have industry partners as in German Bio Regio initiative where funding was given only if different actors (universities and companies) from the region were involved and interacted.) and 2) seminar activities within programs.

Human capital

Many government instruments focus on getting "the right type of people in the right places". Globalization means that people and companies are more mobile and have greater flexibility. Companies do not find many obstacles to move their operations to areas where skills supply is of higher quality or available in larger quantities. It is clear that governments try to halt this potential evasion of business and people by developing the supply side of human capital. The main way to do this is through educational policy. However, there are also other types of instruments related to this that aim at 1) attracting people with the right skills from foreign countries, 2) stimulating people's foreign exposure by sending them abroad to gain experience and knowledge, and 3) providing favorable conditions to avoid brain drain.

[7] One should note that regions such as Silicon Valley emerge also without any government intervention.

AUSTRIA: ECOPROFIT Graz
(promoting regional networking in Austria)

In 1991, the Graz University of Technology designed and conducted a Cleaner Production project in co-operation with local companies. The project was one part of Austria's PREPARE program (Preventive Environmental Protection Approach in Europe). In the beginning, the project was only a research oriented case-study involving five small companies in Graz region. The goal was to jointly figure out methods or measures which were able to introduce cleaner production to SMEs as well as create economic benefit to companies and to the City of Graz.

The case-study was very successful and Stenum ltd. (private engineering consultancy) was founded to continue these activities and ECOPROFIT became a long-term project on a much broader basis getting funds partly from the City of Graz. Nowadays more than 60 small, medium, and large Graz companies from different industry sectors have already participated in the ECOPROFIT beginners' program (including workshops, consulting services and process to apply for cleaner product award). Meanwhile the concept of the program has been copied and transferred to a number of other cities and regions (including a Bavarian ECOPROFIT adaptation).

The ECOPROFIT program consists of three elements:

- Networking among local companies is increased by including all major regional actors such as public authorities, research institutes and the University of Graz, consultants, and companies. Networking is facilitated through **ECOPROFIT Club Graz** that creates an institutionalized discussion and meeting platform.

- A special regional **Cleaner Products Award** has been donated to a number of companies on a yearly basis since 1993. The award is a strong sign of the company's environmental friendly production. To achieve this award several ecological and organizational criteria have to be fulfilled. The award helps the companies' project managers to get a better commitment from the top management and to get a higher acceptance for the program among the employees. In many cases, this award helped the companies to demonstrate to clients that they are working in the field of environmental improvement. The award is donated by a committee in which all important local actors are involved. This helps to find a broader acceptance for the award and also partly encourages networking among actors.

- **Specific learning units** have an emphasis on implementation by individual consulting and institutionalized platforms for the exchange of experience. Experience showed that these learning units enable the education and training of the participants as well as the implementation of long-term Cleaner Product activities. Also it helped to reduce waste and emissions significantly.

Different types of instruments related to these issues are:

- Instruments aimed at increasing mobility of researchers: funding to go away from a country for a while, research exchange grants, EU researcher mobility programs, encourage students to do doctoral training abroad (combined with incentives to "come back home").
- Attract foreign skilled work force (already ready to work). For example, U.S. instruments to attract IT workforce (easy to get visas), income taxation benefits for foreign experts such as in the Netherlands where 35% of the income of a foreign expert with special skills (not specified in detail) is tax free for 10 years in the country.
- Attract foreign students: create study programs in English, increase number of in-take of foreign students at graduate and post-graduate level.
- Attract foreign researchers (investors) by establishing centers of excellence with international reputation (this can be an important support to promote or to give needed funds for international top skills within a country).
- Establish research institutes abroad in order to provide a channel for knowledge transfer. One way to do this is to participate in funding international joint research centers, such as

CERN or ESA. However, even more extreme and proactive measures can be taken. The Korean government has established abroad seven joint research facilities in bilateral collaboration with foreign governments. The biggest is located in Germany and focuses on environmental technologies (OECD, 1999). National research institutes open branches abroad to attract more international contract funding (example of the Frauenhofer Institute in Germany opening branch laboratories in North America and Asia.)

Create new business and support business operations

One important problem area in all countries is the nurturing of SMEs where much of the innovation capacity is located and which generate the majority of the employment opportunities. The most important instrument is providing capital for setting up a new business. However, governments have a variety of instruments to provide knowledge to start small businesses (especially help for starting innovation companies generated at universities), providing information about issues for which SMEs do not have resources to find themselves (related to networking with other companies and universities), offering strategic business help (services around business operations). Many of these instruments also benefit bigger companies. Particularly the provision of information is not necessarily limited to SMEs.

Help to start:

- To make starting up easier by provision of information and support. Several countries have different instruments for the active provision of support and advice to aid commercialization.
- Matching services to find partners (possible sub-contractors, synergy with other types of companies using same technologies, contacts to research units, contacts with financiers).
- Incubators as described in connection with networking.

Other information and services:

- Information collection and dissemination on relevant issues. (The United States ETV program presents an example of an environmental technologies verification program in U.S. that had multiple goals of helping market entry of new technologies and supporting networking.)
- Patenting services
- Market analyses

UNITED STATES: ENVIRONMENTAL TECHNOLOGY VERIFICATION (ETV) PROGRAM

The US Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program seeks to provide objective, replicable, independent **performance data** for new commercial ready environmental technologies to help reduce the time it takes to gain market acceptance. It is entirely voluntary for technology suppliers. The program does not certify (guarantee) performance for regulatory purposes, nor does it seek to establish performance standards for new environmental technologies. Technologies must be commercial ready, funds for technology R&D are not provided.

Environmental technologies addressed by the program cover a broad spectrum including avoidance, control, monitoring and remediation technologies for air, soil and water. This program addresses market introduction of new technologies that may improve existing products and processes, redesign of products and processes or address function and system innovation.

There are five operating principles for the program:

- Testing will be available to and consistent for all vendors of commercial-ready technologies within defined categories.
- All ETV test will be conducted by objective, third party testing organizations having no financial or other interests in the technology.
- Pre-existing, publicly available test plans will be used throughout the program.
- Results of all ETV evaluations will be published in reports that are available to all interested parties.
- All ETV pilots will operate under a quality management plan and through quality assurance procedures that ensure the production of data of an acceptable level for verification.

The program was developed because consistent, independently provided information on new environmental technologies does not exist. This information is especially important to have for environmental technologies because of the associated health and environmental risks. For certain classes of environmental technology, the regulated marketplace segments markets, adds uncertainty, and lengthens the time to new technology acceptance.

The ETV program is structured to be a two-phased ten year program. The pilot phase, lasting from 1995 to 2000 is purposely structured to experiment with a variety of partners and procedures. Twelve pilots covering 16 technology areas have been developed in this phase. They were selected based on an assessment of their contribution to environmental protection and potential market opportunities. Unless the experimental phase suggests otherwise, the program will eventually be privately funded (companies pay testing expenses) and operated with minimal, yet crucial, EPA participation at a target of $3 to 4 million per year. EPA will always provide quality assurance.

Stakeholder groups of vendors, purchasers, state representatives, consulting engineers, and the financial community provide input into the program on technology priorities, performance parameters required for decision making, test protocols, and information dissemination. The stakeholder input is considered critical to the program design. The make-up of the stakeholder groups vary by pilot and range in size from 16 to 179 members averaging 64 members. These groups provide class knowledge, improve the program's credibility, and develop buy-in. The ultimate decisions on technology areas and protocols are made by the EPA with its partners based on the supply of technologies, estimated environmental benefits and practicality given time and budget constraints. In many areas--where one company has a large market share, where technologies are not sold or licensed, etc.-- the market would not benefit from a verification program.

Participatory instruments

Participatory instruments provide government with an opportunity to take a more active role than only providing funds or support for the private sector by participating in risk taking and sharing some of the benefits. Different public private partnership (PPP) instruments stimulating innovation mainly focus on sharing the risk in one way or the other. Through government participation time horizons can be extended and instrument can lead to sliding cost-share basis (shares being determined by technological maturity). However, increased participation is not only a question of governments taking more risk, but they also may

benefit by moving some of their responsibilities to private parties. From the government point of view, increased efficiency is often used as an argument to let a private party complete part of a task.

Examples of PPP related instruments include:

- Partnership programs between authorities and industry to test new technologies (e.g., safety related) and establish standards regarding their performance.
- PPP projects to highlight cross-technology, multidisciplinarity issues, bring together private parties that would not cooperate in other ways. Demonstration effect of complex technological systems.
- Allow full participation by and rotation of government employees to technology development projects
- Targeted regional and community level instruments to activate regional/community authorities to join forces with private parties (see also the earlier example in Austria in the city of Graz.)

In the following, a set of procurement related instruments is described that were found to be interesting in a study (RAND Europe, 1997) because of their extent, apparent success, widespread emulation, and/or clever approach. They were not part of the inventory of the current study but provide appropriate complementary information to the selected initiatives.

Green Procurement

Many nations have instituted programs intended to foster the development of environmentally friendly products and production processes by providing a core of market demand. These programs have evidently succeeded, based on their widespread use and indirect evidence about the development and dissemination of new ideas in countries that follow them. In most cases, they "piggyback" on existing procurement programs by mandating standards for a wide range of government procurement activities. In addition to mandating standards, the responsible organization typically provides guidance for government officers and imposes reporting requirements.

The crux of the Green Procurement initiatives is that potential suppliers of environmentally friendly goods are assured of a sustained and healthy market for their products, and are often given quite explicit guidance as to what steps are required to win government contracts.

In 1997, RAND Europe compared green procurement instruments in Denmark, the UK and the U.S. All three countries share the objective of increasing government use of environmentally friendly goods and services. The mechanisms chosen vary; all three nations use a mixture of demonstration projects, procurement standards and formal plans, but the degree of compulsion and the coverage of these varies widely. At a deeper level, the programs differ as to the extent to which: i) supply considerations are integrated with demand considerations; ii) the policies can be seen as a part of larger environmental policy; and iii) these policies broaden the scope of general project costing to include environmental costs. Within Box 7 is presented an example of a specific green procurement instrument of U.S. procurement of Alternative-fueled Vehicles.

UNITED STATES: PROCUREMENT OF ALTERNATIVE-FUELED VEHICLES (AFV)

In response to the various oil price shocks of the past three decades, the rapid depletion of fossil fuel sources and growing concern for the environmental impact of mobile-source emissions, the US government has developed a number of policies aimed at encouraging the development and use of alternative fuels. Early initiatives had a strong research support component. Two later programs, laid out in the National Energy Policy Act of 1992 and a subsequent Executive Order are explicitly oriented to procurement of alternative fueled vehicles (AFVs).

The primary strategic objectives of programs are:

- reduced atmospheric pollution and vehicle maintenance costs;
- increased domestic economic activity,
- job creation and
- domestic fuel source use.

Secondary goals include market impetus for the development and manufacture of AFVs and expansion of the fueling infrastructure necessary for privately owned AFVs. From a technological innovation point of view, the program can be characterized as an attempt to help new technologies achieve "critical mass" in terms of manufacturing scale and market penetration. Over time, it is hoped that the market for AFVs will cease to be dependent on government sales.

The government is by far the largest single buyer of AFVs. The program involves a targeted acquisition of AFVs by federal agencies maintaining vehicle fleets. The government also uses regulatory and planning mechanisms to facilitate construction of the required fueling infrastructure, which in turn will lower entry costs and increased perceived demand for producers of alternative fuels. Finally, in certain areas of the country (e.g. the Los Angeles Air Quality Management District), tight government emissions standards for mobile pollution sources (such as motor vehicles) provide an extra impetus to the purchase of AFVs by local government and the private sector.

Re-organizing government procurement to stimulate innovation

A further example demonstrates how a government can re-organize part of its procurement process to be more focused on stimulating innovation and that take environmental objectives into consideration. Denmark found a solution in moving most of the procurement activities to be handled through a private company. In this way, some of the restrictions set by EU can be

PROCUREMENT AGENCY IN DENMARK

National Procurement (NP), Ltd. (Denmark) is a publicly owned private sector organization that handles much of the Danish procurement. The privatized structure offers advantages in terms of, for example, avoiding the expense and delay associated with repetitive tenders of the sort required by EU Procurement policy. Organization's goals are:

- efficiency (reduction in procurement cost and purchase prices);
- environmental friendliness;
- electronic document interchange; and
- financial self-sufficiency.

The organization has a large catalogue of items ranging across the whole spectrum of goods bought by the government. While the overall goals of the organization are not directly oriented towards innovation, certain product characteristics (e.g. environmental friendliness), product lines, (e.g., office furniture), and procurement practices are highlighted in ways that encourage producers to supply innovative products.

NP is creating an extensive decision support system, where users will be linked through a distributed decision environment (over the Internet). The offerings of the different vendors with whom NP has negotiated frame contracts are incorporated into the organization's catalogue. Government clients then make their purchases from this listing, using listed details of the products' environmental characteristics, etc.

avoided. In Germany, a government program was set up to recognize areas where greater spill-over benefits can be achieved by procurement.

4.4.3. Instruments relating to the legal framework

Many governments use various technology incentives as an important component of their pollution abatement strategies. These "carrots" are intended to encourage the initial diffusion of new, emissions-reducing technologies. In contrast, pollution taxes and emissions trading which provide a "stick" designed to reduce emissions by increasing the price of high-emitting technologies for all users. The rationale for these types of measures is that in the absence of regulation, firms may lack incentives to adopt technologies that produce environmental benefits.

The discussion of the state of debate (see section 4.3.) demonstrated that the emphasis of the traditional use of legislative and regulatory instruments have become less prominent and desirable although their role can still be important and they often are supportive instruments in combination with other instruments. Also with increased globalization and networking, harmonization of these instruments and coordination among governments become very important issues as they can possible affect the effectiveness of the instrument.

Legislative and regulatory instruments with respect to sustainable development have originally been oriented toward pollution control more than prevention. The incentives for innovation were therefore mostly directed to energy efficiency and end-of-pipe technology. As described in the previous chapter, some countries still use legislation primarily for pollution control

Governments have now begun to re-engineer their legislative efforts and introduced more pro-active and stimulating types of legislation and regulation or incorporate economic instruments into legislative environments. Rather than the punitive character, legislation has included more awarding incentives. Also, the formulation of outcome oriented specifications have become more important than process controls and requirements. The German Renewable Electricity Laws (highlighted below) and the British Energy Efficiency Standard of Performance are good examples of the revised use of regulatory instruments.

Finally, self-regulatory instruments have become increasingly popular as a compliance tool to environmental standards. The role of government here is not so much to design and enforce legislation as well as to create and maintain the level playing field among private sector parties and to oversee and measure the direction toward societal goals. Green labeling, setting performance standards, and designing emissions trading schemes are additional instruments that the surveyed countries have applied to a different extent.

Green labeling efforts focus their activities on developing marketability for green products. Governments often financial support organizations in applying for the labeling of their products. Performance standards as formulated in the UK by the EESOP program (see country report for details) aim at providing certain objectives for energy efficiency. Finally, it has been suggested that the costs saved in trading provide new revenues for developing innovative technology approaches for direct use in further improving environmental quality. However, only in a few countries that we surveyed, serious efforts are underway to introduce these systems. The United Kingdom and Denmark are furthest along in their initiatives.

GERMANY: RENEWABLE ELECTRICITY LAWS

The goal of these federal laws is to support R&D on and the implementation of wind energy systems in Germany. Private households or companies get a financial support if they generate wind (or other renewable) electricity themselves. They get this financial support from the energy suppliers which are forced by the Renewable Electricity Laws to buy this electricity for a certain (given) amount per kWh. These laws are part of a policy-mix combining direct financial support, cheap loans, tax reductions as well as given prices for renewable electricity. Altogether these measures took several years (the laws for renewable electricity are still in force) and were quite successful. The instruments focus on market introduction as well as on the improvement of existing products and processes.

The first Renewable Electricity Law came into force on a federal level in 1991. It was implemented because on the one hand side functioning and reliable technological solutions for the use of wind energy existed, but on the other hand side the German energy suppliers did not want to use such systems - even if they could benefit from public financial support. The main reason for this was the centralized German energy supply system with its need for big power plants. As a result wind energy systems were not implemented on a broad basis.

Therefore the Federal Ministry for Science and Technology had the idea to financially support private households or companies if they generate wind (or other renewable) electricity themselves. The energy suppliers were forced by law to buy this electricity for a certain (given) amount of money per kWh.

4.4.4. Methods to measure effectiveness

The focus on assessment of government programs in the field of sustainable development has increased considerably. Assessment and evaluations have been accepted as a tool to assist in policymaking and adjusting current programs. In most countries it has resulted in regular evaluation exercises conducted by external parties according to standardized procedures. Thus, the European Commission has a de facto standardized approach for most evaluations it requests: the Logical Framework Methodology; in Denmark, the Finance Ministry has defined a common procedure; and in Sweden, there is a national evaluation organization (RRV) that provides recommendations for future developments and the types of instruments that should be supported based on the evaluated performance of existing programs.

Some more market related mechanisms can be measured in their economic and environmental performance. The market trading mechanisms can be evaluated in terms of how well environmental goals have been reached. This can be measured primarily by determining the extent to which emission levels have been reduced, and at what cost. It also can be measured in terms of improved levels of relevant air pollutant concentrations, the resulting acid deposition levels with reduced environmental damages.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. GENERAL TRENDS IN ADVANCED COUNTRIES

Several trends have emerged from our analysis of the efforts to stimulate innovation in industry for sustainability. A key to our observations is the distinction between countries that have not yet adapted the paradigm shift regarding the environmental burden of economic activity and those that have. This latter group, which we term "mature" provides experiences that are of potential value to the Dutch. Unfortunately, while the mature countries manifest more advanced thinking, we have found no indication that the instruments that they use and the themes that they focus on are more effective in reaching goals pertaining to sustainable development. As a matter of fact, it is exactly the absence of these indications that stress the need for more intensive research and evaluation of the impact of the newer types of instruments. However, these more mature countries tend to provide more surprising or innovative mechanisms that could be helpful for the Dutch government in assessing adjustment to the existing set of Dutch programs and instruments.

- **Gradual shift from basic research to implementation (… and back?)**

Although we have observed that the distinction between different stages of innovation have become blurred, governments have a tendency to provide increasing support to initiatives on a project by project basis and with more practically oriented objectives than to basic scientific research. The proportion of public support used to fund higher education research, an important source for basic research, is high and stable in Austria and France, but shrinking elsewhere.[8] Specific research centers or centers of excellence for applied R&D activities have spread rapidly. The greater importance and involvement of industries and the increased awareness of connecting public and private actors have also created more emphasis on the need for more market-oriented product development and implementation than on basic research. This finding, which holds for R&D investment in general, is particularly true for investment oriented towards sustainability.

SMEs have always been important in the United States as promoters of innovation and technology development in many areas, including environmental technology. They are the traditional American risk-takers, who reap large benefits (in terms of wealth for themselves, jobs for society, and benefits realized by consumption of the products they introduce) when they are successful and acquire little shame when they fail. This role of SMEs is becoming increasingly prominent in a number of European countries. However, SMEs, unlike larger firms, need support in all phases of their operations. They usually have fewer resources and they face relatively higher risks compared to large companies (e.g., the future of a start-up company is often dependent on the success of the first R&D project). Many government instruments are thus targeted to sharing the risks of SMEs. The main bottlenecks and areas where support is needed in SMEs are moving from technological development to product innovation and delivery. This seems to be the strategic direction where many countries are increasing support activities (i.e., instruments are more targeted to help market entry and to provide strategic business services).

However, while governments have shifted their attention toward funding more application-oriented activities, concerns are raised by industry that funding basic research and the knowledge infrastructure is neglected. As a consequence a skilled labor force becomes less available, undermining technology development in the private sector in the long run.

---

[8] Cave, J., E. Frinking, K. Malone, W. van Rossum, and R. te Velde, Modalities of R&D Funding: A Comparison of EU Member State*s*, RAND Europe, Leiden, 1999

- **Greater emphasis on promoting knowledge transfer and public-private partnerships**

Many countries still direct considerable resources to funding the knowledge infrastructure and supporting basic research and technological development. However, governments increasingly use a wider set of instruments to promote the dissemination of knowledge about technology development and the establishment of public-private partnerships (PPPs). Knowledge diffusion and PPPs can assist in overcoming information gaps, involving smaller firms in the innovation processes, demonstrating the cost-effectiveness of sustainable technologies, and benchmarking the overall performance of new products. The programs used to serve this purpose are varied, but a considerable emphasis is put on establishing networks joining smaller and larger enterprises, private sector research and public research institutes, as well as providing guidelines and standards to support business operations. While the real effects of these instruments on technology development and implementation are sometimes hard to measure, the involved parties are often very pleased with the concrete aspects of the cooperation.

- **Emphasis on combination of policy instruments**

A reorientation of instruments used for stimulating sustainable development and innovation has taken place. The current strategies are very much pushing a multi-instrument approach rather than a single instrument approach. This is clearly in line with the discussion in the previous chapter that the thinking of innovation and technology development as a "pipeline", in which a specific incentive leads to a specific effect, has in the last decade been mostly abandoned. It might appear that once a systems orientation has been adopted with regard to the output of innovation, there is receptivity to the same orientation to guide inputs for promoting innovation.

- **Increased use of market processes (e.g. voluntary, green labeling)**

An important bottleneck in the development of environmental technologies has been the social-cultural acceptability of innovative green products. Building the capacity to develop products and processes that reduce the environmental burden and remain cost-effective has now become more feasible, but development of a "green" market to make viable and promote the use of green products is now increasingly becoming a focus of attention. As governments attempt to realize the objectives of presenting the benefits of new technologies and verifying their technical feasibility, the number of green labeling programs and the development of standards from the perspective of potential users are increasing.

- **Sustainable development as an integral part of policymaking**

Governments that have put high priorities on sustainable development issues are pursuing a strategy that actively integrates sustainability in all sector policies. While some countries still maintain large programs and initiatives directed uniquely to sustainable development, newer initiatives—including some markedly successful ones—aim at incorporating sustainable development concerns in the policymaking processes in the areas of agriculture, energy, transportation, and commerce.

5.2. NOBODY IS THERE YET

Despite the perceived progress made in several countries, there are still remaining problems that will need resolution.

- **Link between specific technology expertise and business development**

As indicated above, there are increasing efforts to link scientific institutes with the research base of companies. This can be considered a first step to connect basic research activities and technology development. Problems still exist in generating money to support operations between the phase of early product development and the phase when the products become marketable. Government organizations that have to select and prioritize ideas and products

increasingly face a limited capacity to assess projects comprehensively on their technological, social and commercial merits. Despite the successful use of specialized intermediary agencies who possess that comprehensive capacity, government organizations are experiencing side effects in terms of difficulty keeping up with technological developments and getting slowed down by bureaucratic procedures. In some countries, this has started discussions about the role of these organizations and the instruments they apply.

- **Effects of the use of instruments on innovation in industry is rather unclear**

Many programs and initiatives that we highlighted in this international survey have only recently been implemented. Often there is only sparse information available to conduct an evaluation ex-post. Thus, currently available assessments do not provide the opportunity to determine the long-term impacts and sustainability of certain technologies. It is therefore premature to evaluate their effects on innovation. The development of indicators, comparable across countries, to trace the performance of programs could be a valuable methodological exercise.

- **Industries do not always accept the objectives and designs of government programs**

As markets for technological innovation become more mature, the availability of venture capital is increasing. This makes support from government less attractive, especially if that support comes with regulatory strings attached. As a consequence, even though governments might still be prepared to allocate large budgets to the funding of basic research and technology development in the private sector, these funds could go begging, especially in ventures considered to have relatively lower risk. Some observers have suggested that governments might focus on more high-risk ventures. At this moment there are only a few initiatives aimed in that direction.

5.3. RECOMMENDATIONS

Based on our experiences with the countries that were included in our survey and our understanding of the Dutch policy context, we can conclude with some recommendations for Dutch policy.

- **Nobody else is the Netherlands**

None of the examined countries provides a model for which the Netherlands should be aiming. As indicated in Table 4.4, we found in an examination of ten different countries ten different ways in which the government engages technology development, sustainability, and the private sector. Different policy philosophies and different national characteristics only add to this already varied picture and make imitation more a harmful than a fruitful approach. In addition, some of the countries that could be interesting as potential models (e.g., Sweden, Finland) are currently undergoing discussions about reforming their own structures, often looking to the Netherlands for inspiration.

- **Choose a diverse mix à la carte**

While there is no specific country model to be followed, we have encountered many interesting programs and initiatives covering a wide range of possibilities (see Table 4.1 and the accompanying document describing these programs). Given the increasing emphasis that is being put on a multi-instrument approach, it would seem most valuable to cover all bases, being inspired by the most interesting cases.

Among the cases presented, highly focused projects seem to be a key to success. The focus itself can vary widely, depending on the individual project, concentrating on:

- **geographic scope** (e.g. focus on regional or even community level instead of on the national level); In some of the countries involved in this study highly successful projects have been launched on regional and city levels (e.g. Austria and Germany)

- **small changes;** incremental, bottom-up changes seem to have better results than revolutionary changes, since acceptance (both by the public, industry and the political arena) is crucial (see Sweden). This is especially true when large technological changes have significant cultural resistance (e.g., genetically modified foods).
- **specific well-defined sectors of industry**; e.g. programs with a clear focus on SMEs or a particular industry seem to have a relatively high chance for success, compared to more general programs in which all kinds of industries are involved.

At the same time, ongoing efforts to mobilize large international teams or large-scale efforts should certainly not be abandoned. However, these larger efforts will eventually require implementation in more tightly defined geographical and sectoral areas.

While the Dutch portfolio in the area of sustainable development already covers a wide range of instruments, the "green procurement" instrument seems relatively unused in the Netherlands. In addition, there is empirical evidence that emission trading schemes, not fully developed in the Netherlands, have positive impacts on innovation and/or investment in technology development. The preparatory efforts in the Netherlands for the introduction of these schemes therefore seem worthwhile to continue.

- **Include industry in priority setting**

It is not a great insight to realize that the objectives and priorities of governments and private sector organizations are different, but taking those differences into account in instrument implementation is an art that is not fully realized. Although a company might be interested in incorporating issues such as preserving the environment in their objectives, not many businesses are ready to invest in the environment if they do not consider it economically feasible. Changing societal values and the environmental awareness of consumers might actually induce industries to invest in sustainable technology. Governments can play a role in creating mutual understanding of values and priorities, while industries can inform about the feasibility and viability of promoting certain technologies. Public-private partnerships are important vehicles but the inclusion of industry in priority setting remains important. This involvement should not ignore issues, which may create situations where government and industry goals could clearly conflict:

- There is often a failure by the private sector to recognize the economic benefit of producing goods and services with positive societal impacts. How strong a government intervention is needed to create awareness?
- New products or services that may have adverse societal impacts (e.g., genetically modified food, use of mobile phones by children, automobiles) often arrive relatively unscrutinized at the marketplace. When should government prevent the launch of a product or restrict its scope? When should government decide not to support R&D of a product? When should government prevent R&D of a product?
- R&D activities can conflict with societal goals (clinical tests with humans, animals). When should government step in?
- There are legal and ethical issues raised regarding intellectual property rights related to knowledge produced with public funds. These issues call for understanding the best balance between industry's desire to protect some of its knowledge and the desire of the society to have access to information.

- **Learn how society can be receptive to promoting sustainable technology**

Open exchange of information is crucial to stimulate sustainable innovation in industry. However, we don't know yet the answer to the question**:** What causes a **population** to be receptive to promoting sustainable technology? This might have to do with attitude of a population toward sustainability and environmental issues, which might be related to the economic well-being of the country (now and in the past), in combination with the organizational and constitutional structure of a country etc. We noted differences in the

maturity of developed European countries in adopting the paradigm shift of sustainability, but none of our analyses—nor country categorizations in the innovation literature—successfully explained which countries adopted and which countries did not adopt the paradigm shift or why this happened. While certain countries have established initiatives to focus production of new technology that are based on the functionality and requirements that users might want, most countries still follow the path of developing those technologies that are most easily developed. No clear answer has emerged from our research, but this would seem to be one of the most fundamental issues in stimulating and accepting innovation for sustainability.

6. REFERENCES

In addition to the references mentioned in the individual country reports, the following sources were consulted:

Amable, B. Barré, R. and Boyer, R. *Les Systèmes d'innovation à l'ère de la Globalization,* Economica, Paris, 1997.

Cave, J., E. Frinking, K. Malone, W. van Rossum, and R. te Velde, *Modalities of R&D Funding: A Comparison of EU Member States*, RAND Europe, Leiden, 1999.

Commission of the European Communities, *Towards a European research area*, COM (2000) 6, Brusssels, January 2000.

European Commission, *Second European Report on Science and Technology Indicators*, 1997.

OECD, *Basic Science and Technology Statistics*, OECD, Paris, 1997.

OECD, *Fiscal Measures to Promote R&D and Innovation*, OECD/GD(96)165, 1996.

OECD, *Government Venture Capital for Technology-Based Firms*, OECD/GD(97)201, 1997.

OECD, *Globalization of Industrial R&D: Policy Issues*, OECD, 1999.

OECD, *Main Science and Technology Indicators*, OECD, Paris 1997.

OECD, Science, *Technology and Industry Outlook 1998*, OECD DSTI/STP(99)19/final, Paris 1998.

OECD, *Technology and Environment: Towards Policy Integration*, OECD, Paris 1999

Popper, S., C. Wagner, and E. Larson, *New Forces at Work - Industry Views Critical Technologies*, RAND Critical Technologies Institute, 1998.

RAND Europe, *Government as a Launching Customer: An International Survey of Public Procurement of Innovative Goods and Services*, RE-97.11, RAND Europe, Delft, 1997.

RAND Europe and Coopers & Lybrand, *Technology Radar: Volume 1 - Executive Summary*, Delft, 1998a.

RAND Europe and Coopers & Lybrand, *Technology Radar: Volume 4 - Global Views on Strategic Technologies*, Delft, 1998b.

RAND, Draft on U.S. innovation policies, Caroline Wagner and Bruce Don, October, 1999.

RAND Europe, "Tekes developing future strategies", Leiden, 2000.

Resetar, S., *Technology Forces at Work - Profiles of Environmental Research and Development at DuPont, Intel, Mosanto, and Xerox*, RAND Science and Technology Policy Institute, Washington DC, 1999.

United Kingdom Office of Science and Technology (1995). *Progress through Partnership: Report from the Steering Group of the Technology Foresight Program 1995*, Office of Science and Technology, HMSO, London.

Wagner, C., *International Alliances and Technology Transfer: Challenging National Foresight?,* DRR-2096-OSTP, RAND, 1999.

White House Office of Science and Technology Policy and National Critical Technologies Review Group, *The National Critical Technologies Report*, Washington, D.C, 1995.